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AUTHOR Hull, Daniel M.
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ABSTRACT

A study was conducted to assist two-year postsecondary educational institutions in providing technical specialty courses for preparing nuclear technicians. As a result of project activities, curricula have been developed for five categories of nuclear technicians and operators: (1) radiation protection technician, (2) nuclear instrumentation and control technician, (3) nuclear materials processing technician, (4) nuclear quality assurance/quality control technician, and (5) nuclear reactor (plant) operator trainee. The total Nuclear Technology Series consists of 236 instructional modules for 35 technical specialty courses. In addition, program planning guides were developed for each of the curriculum areas. (Appended material includes curriculum outlines, course descriptions and module objectives for Nuclear Radiation Production, Nuclear Instrumentation and Control, and Nuclear Materials Processing Technologies.) (LRA)

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FINAL REPORT

Contract No. 300780582

DEVELOPMENT OF CURRICULA FOR NUCLEAR RADIATION PROTECTION, NUCLEAR INSTRUMENTATION, AND NUCLEAR MATERIALS PROCESSING TECHNOLOGIES

Daniel M. Hull

Technical Education Research Center — Southwest
4800 Lakewood Drive
Waco, Texas 76710

September 1980

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The activity which is the subject of this report was supported in whole or in part by the U.S. Department of Education, The Office of Vocational and Adult Education, Division of Research and Demonstration, Curriculum Development Branch, pursuant to Contract No. 300780582. However, the opinions expressed herein do not necessarily reflect the position or policy of the Department of Education, and no official endorsement by the Department of Education should be inferred.

ABSTRACT

Almost 200 nuclear power plants are either in operation or currently under construction. The need for operators and technicians to work in these plants will increase dramatically in the next decade. Technicians are also needed in research establishments and facilities required to process or reprocess nuclear fuels. The technical preparation of this workforce can be provided by combinations of high-quality educational programs at two-year, post-secondary institutions and in employer training/retraining programs.

Curricula have been designed and instructional materials have been developed for five categories of nuclear technicians and operators. The total Nuclear Technology Series consists of 236 instructional modules for 35 technical specialty courses, some of which were developed under previous contracts. Contract No. 300780582 supported the development of 74 instructional modules and support documents for the curricula listed:

Radiation Protection Technician —
Courses 17 through 22 (39 modules and six course indexes)
Program Planning Guide.

Nuclear Instrumentation and Control Technician —
Courses 33 through 35 (20 modules and three course indexes)
Program Planning Guide.

Nuclear Materials Processing Technician —
Courses 23 through 25 (15 modules and 3 course indexes)
Program Planning Guide.

Nuclear Quality-Assurance/Quality-Control Technician —
Program Planning Guide
Indexes for seven previously developed courses.

Nuclear Reactor (Plant) Operator Trainee —
Minor revisions to Program Planning Guide
Indexes for 16 previously developed courses.

Master Index (an integrated index to all 35 courses).

Instructional modules for courses 1 through 16 and 26 through 32 were developed under separate contracts, but are a part of the 35-course Nuclear Technology Series. (Refer to Table 1, "Nuclear Series Courses and Supporting Publications.")

Dissemination activities have been conducted, resulting in contacts with 44 public and private training organizations and the utilization of 8,577 copies of instructional materials.

All tasks for the referenced contract have been completed. This Final Report describes the background data, development procedure, and deliverable items and offers recommendations for future work.

PREFACE

In recent years, peacetime applications of Nuclear Technology have focused upon the use of nuclear fission as an energy source for electrical power plants. In 1980, 70 nuclear-fueled generating units provided approximately 15 percent of this country's electrical power; by the end of the decade over 180 nuclear units are scheduled to provide 25 percent of our electricity. To build and operate these plants safely and efficiently, and to process their fuel, requires a workforce of well trained operators and technicians.

Potential sources of training for this rapidly growing workforce are two-year vocational/technical education programs offered by public, postsecondary educational institutions. To assist these institutions in providing the technical specialty courses for preparing nuclear technicians, the U. S. Department of Education has funded several research and curriculum development projects. These projects have produced 247 instructional modules (over 7,000 pages) for use in 35 courses in five nuclear technician curriculum areas.

This final report reviews the accomplishments of prior projects and describes the procedures and products of the current project to complete the development of the curriculum materials and conduct limited dissemination activities for the five nuclear curricula.

Key TERC-SW staff who contributed to this project were Mr. Vernon Woolf, Associate Project Director, Mr. Ellis Lindsey, Research Associate/Editor, and Ms. Kay Liston, Project Coordinator.

Daniel M. Hull
Project Director

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INTRODUCTION

Nuclear energy has brought to our country a realistic, alternative source of fueling electrical power plants. But the continued necessary growth in this vital area requires a well prepared workforce of technical support personnel to operate nuclear power plants efficiently and safely.

Nuclear fission – atom splitting – generates heat, providing an energy source for electrical plants. Its worldwide impact is rapidly increasing. At mid-1980, sixty-seven on-line nuclear-fueled plants provided about thirteen percent of America's electrical power. This percentage is expected to double by 1990. Outside the United States, nations on nearly every continent are looking to nuclear fission for electrical power generation.

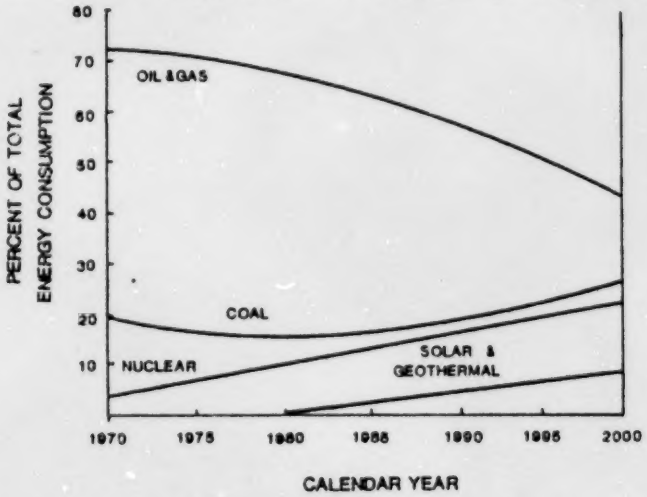

Figure 1. Projected consumption of various energy sources.

Nuclear technology has passed the state of basic research through the phase of applied research and into an era of practical application. The first nuclear-fired electrical plant came on-line in 1958 in Shippingport, Pennsylvania. But nuclear fission had already proved its capability as a useful power source aboard the submarine, USS Nautilus. The first nuclear-powered vessel began its sea trials in 1955. Many of the industry's early nuclear operators and technicians were former seamen from the Navy's extensive nuclear fleet.

However, in the past decade, the electrical power industry has found this workforce supply to be insufficient to meet its increasing demands. Efforts to retrain operators and technical personnel from existing fossil-fueled plants have proven to be very expensive and of limited success.

In 1979 twenty-one technical-vocational schools offered programs to train nuclear technicians. But industry needs for trained nuclear technicians far exceeds the graduates produced by these few programs. And ingress into industry from the Navy has dwindled to an ineffective trickle.

PRIOR WORK

In July 1974, the Technical Education Research Center – Southwest (TERC-SW) received a grant* from the U. S. Office of Education to conduct educational research in Nuclear Technology. To guide this research and to provide necessary data, the National Steering Committee for Nuclear Technician Training was formed, and meetings were held at intervals of approximately six months. (Refer to the section, Project Advisory Committee.)

The studies conducted under this grant identified five categories of energy-related nuclear technicians:

- Nuclear Reactor (Plant) Operator Trainee.
- Radiation Protection Technician.
- Nuclear Materials Processing Technician.
- Nuclear Quality Assurance/Quality Control Technician.
- Nuclear Instrumentation and Control Technician.

For the purpose of training at postsecondary institutions, TERC-SW prepared for each job category, (1) task lists and required knowledge, (2) curriculum outlines, by quarters, and (3) descriptions of all courses in the curriculum outlines. The curricula were examined to identify those "nuclear technology specialty courses" which were not usually taught at two-year, postsecondary institutions and for which suitable instructional materials were not available. Thirty-four specialty courses were identified in the five curricula (most of the courses were included in more than one curriculum). These courses were divided into 235 modular units, and outlines were prepared for modular instructional materials, based upon learning objectives derived from the tasks lists and required knowledge for the job categories.

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*Project No. V0003VZ, Grant No. OE6-74-/679, "Development, Evaluation, and Dissemination of a Postsecondary Program in Nuclear Technology." conducted by Technical Education Research Center – Southwest, sponsored by the U. S. Department of Health, Education and Welfare, Office of Education, Bureau of Adult and Occupational Education, July 1, 1974 – April 30, 1976.

Also developed on this grant were twelve instructional modules for Course 1, "Radiation Physics," and Course 2, "Radiation Protection I."

Finally, a Nuclear Technology Curriculum Development Guide was produced. The guide supplied the specifications for development of instructional materials for the technical specialty courses in each of the five categories of nuclear technicians. A leaflet describing these programs and materials was prepared.

This research work and the project deliverable end items formed the basis of a three-phase effort by the U. S. Office of Education, Department of Health, Education and Welfare, to sponsor the development, evaluation, and dissemination of the Nuclear Technology Series of instructional modules.

1. Contract No. 300760356 with Technical Education Research Center – Southwest (July 1976 - February 1978) provided for the development of 102 instructional modules for the remaining technical specialty courses (Nos. 3 through 16) in the Nuclear Reactor (Plant) Operator Trainee (NROT) curriculum, and the NROT Program Planning Guide.
2. Contract No. 300770340 with General Physics Corporation (October 1977 - December 1979) to develop 57 instructional modules for courses 26 through 32 of the Nuclear Technology Series and to field test courses Nos. 1, 2, 3, 11, 14, 15, and 27. The developed and field tested courses in this project constitute all the technical specialty courses for the Nuclear QA/QC curriculum.
3. The current contract (described in this report) to develop the 74 instructional modules for the remaining courses (Nos. 17 through 25, and 33 through 35) in the Nuclear Technology Series, prepare four Program Planning Guides and conduct dissemination activities.

THE RELATIONSHIP OF THE CURRENT CONTRACT TO THE ENTIRE NUCLEAR PROGRAM

In total, the Nuclear Technology Series encompasses the following curricula for training:

- Nuclear Reactor (Plant) Operator Trainees (NROT).
- Nuclear Radiation Protection Technicians (NRPT).
- Nuclear Instrumentation and Control Technicians (NICT).
- Nuclear Quality-Assurance/Quality Control Technicians (N-QA/QC-T).
- Nuclear Materials Processing Technicians (NMPT).

Previously, TERC-SW had developed the 114 educational modules (Courses 1 through 16) that are required in the NROT curriculum, and the supporting Program Planning Guide and leaflet describing this material. An additional 57 modules (Courses 26 through 32), which complete the technical specialty courses for the N-QA/QC-T curriculum, were developed by General Physics Corportaion. Thus, the remaining materials were developed in this project and consist of the following:

Radiation Protection Technician —
- Courses 17 through 22 (39 modules)
- Program Planning Guide
- Informational leaflet
- Index for each course.

Nuclear Instrumentation and Control Technician —
- Courses 33 through 35 (20 modules)
- Program Planning Guide
- Informational leaflet
- Index for each course.

Nuclear Materials Processing Technician —
- Courses 23 through 25 (15 modules)
- Program Planning Guide
- Informational leaflet
- Index for each course.

Nuclear Quality-Assurance/Quality-Control Technician —
- Program Planning Guide
- Informational leaflet (reformat to meet project requirements)
- Index for each course.

Master Index.

Table 1 clarifies the relationship between the 35 courses of the nuclear series. Table 2 indicates the suggested courses for each of the five curricula. Some courses, especially many of the first 16, are utilized in all or part of the five program areas.

TABLE 1. NUCLEAR SERIES COURSES AND SUPPORTING PUBLICATIONS.

DEPARTMENT OF EDUCATION CONTRACT	COURSES AND SUPPORTING PUBLICATIONS
(Revise) Project No. V0003VZ Grant No. OE6-74/679	1 Radiation Physics (6 Modules) 2 Radiation Protection I (6 Modules)
NUCLEAR REACTOR OPERATOR (TRAINEE) Contract No. 300760356	3 Principles of Process Instrumentation (8 Modules) 4 Heat Transfer and Fluid Flow (9 Modules) 5 Introduction to Nuclear Systems (6 Modules) 6 Instrumentation and Control of Reactors and Plant Systems (6 Modules) 7 Reactor Operatons (7 Modules) 8 Reactor Safety (5 Modules 9 Reactor Auxiliary Systems (4 Modules) 10 Power Plant Systems (9 Modules) 11 Radiation Detection and Measurement (8 Modules) 12 Reactor Physics (8 Modules) 13 Power Plant Chemistry (7 Modules) 14 Introduction to Quality Assurance/Quality Control (9 Modules) 15 Metallurgy and Metals Properties (8 Modules) 16 Mechanical Component Characteristics and Specifications (8 Modules) Nuclear Reactor (Plant) Operator Trainee Program Planning Guide
Contract No. 300780582	Informational leaflet (reformat) Index for each course
RADIATION PROTECTION TECHNICIAN Contract No. 300780582	17 Radiation Protection II (5 Modules) 18 Radiological Emergencies (7 Modules) 19 Radiation Shielding (6 Modules) 20 Radiation Monitoring Techniques (Radiochemical) (7 Modules) 21 Radioactive Monitoring Disposal and Management (7 Modules) 22 Advanced Radionuclide Analysis (7 Modules) Radiation Protection Program Planning Guide Informational leaflet Index for each course
NUCLEAR MATERIALS PROCESSING TECHNICIAN Contract No. 300780582	23 Nuclear Chemical Processes (7 Modules) 24 Nuclear Systems and Safety (6 Modules) 25 Radioactive Material Handling Techniques (8 Modules) Nuclear Materials Processing Technician Program Planning Guide Informational leaflet Index for each course
NUCLEAR QUALITY-ASSURANCE QUALITY-CONTROL TECHNICIAN (Developed by General Physics Corporation) Contract No. 300770340	26 Nondestructive Examination (NDE) Techniques I (7 Modules) 27 Metrology (7 Modules) 28 Welding Inspection (10 Modules) 29 Civil/Structural Inspection (6 Modules) 30 Mechanical Inspection (8 Modules) 31 Quality-Assurance Practices (8 Modules) 32 Nondestructive Examination (NDE) Techniques II (6 Modules)
Contract No. 300780582	Nuclear Quality-Assurance/Quality-Control Technician Program Planning Guide Index for each course Revised informational leaflet
NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN Contract No. 300780582	33 Control Systems I (5 Modules) 34 Control Systems II (7 Modules) 35 Power Plant Electrical Systems and Components (7 Modules) Informational leaflet Index for each course
Contract No. 300780582	Master Index (integrated index to all 35 courses in the Nuclear Series)

TABLE 2. TECHNICAL SPECIALTY COURSES IN THE NUCLEAR TECHNOLOGY SERIES AND THEIR UTILIZATION IN THE FIVE AREAS.

COURSE NO.	TECHNICAL COURSE TITLE	NUMBER OF MODULES	NUCLEAR REACTOR (PLANT) OPERATOR TRAINEE	RADIATION PROTECTION TECHNICIAN	NUCLEAR MATERIALS PROCESSING TECHNICIAN	NUCLEAR QUALITY – ASSURANCE/QUALITY – CONTROL TECHNICIAN	NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN
1	Radiation Physics	6	1	1	1	1	1
2	Radiation Protection I	6	2	2	2	2	2
3	Principles of Process Instrumentation	3	3		3	3	3
4	Heat Transfer and Fluid Flow	3*	3				4
5	Introduction to Nuclear Systems	6	4	3		4	4
6	Instrumentation and Control of Reactors and Plant Systems	8	4				8
7	Reactor Operations	7	6				
8	Reactor Safety	5	5				
9	Reactor Auxiliary Systems	4	8				
10	Power Plant Systems	9	9				
11	Radiation Detection and Measurement	8	2	2	2	2	2
12	Reactor Physics	8	4				4
13	Power Plant Chemistry	7	5	4			
14	Introduction to Quality-Assurance/ Quality-Control	9	3	3	3	3	3
15	Metallurgy and Metals Properties	8	3		4	3	
16	Mechanical Component Characteristics and Specifications	8	4			4	
17	Radiation Protection II	5		4	4		
18	Radiological Emergencies	7		4			
19	Radiation Shielding	6		5			
20	Radiation Monitoring Techniques	7		5	5		
21	Radioactive Materials Disposal and Management	7		5			7
22	Advanced Radionuclide Analysis	7		6			
23	Nuclear Chemical Processes	7			5		
24	Nuclear Systems and Safety	6**			6		
25	Radioactive Material Handling Techniques	8***			6		
26	Nondestructive Examination (NDE) Techniques I	7				4	
27	Metrology	8			3	3	
28	Welding Inspection	11				5	
29	Civil/Structural Inspection	8				5	
30	Mechanical Inspection	9				5	
31	Quality Assurance Practices	8				6	
32	Nondestructive Examination (NDE) Techniques II	6				5	
33	Control Systems I	5					5
34	Control Systems II	7					6
35	Power Plant Electrical Systems and Components	7					6

*Course 4 modified for I&C only.

**Module 24-1 is 12-1
24-2 is 12-2
24-3 is 12-3

***Module 25-6 is 21-1
25-7 is 21-6
25-8 is 21-4

NOTE: Numbers in columns denote suggested quarter for use of the courses.

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PROJECT OBJECTIVES AND ACCOMPLISHMENT OF TASKS

PROJECT OBJECTIVES

The objectives of this project were as follows:

A. To develop the materials needed to complete the curricula and to plan for the installation of programs in the Nuclear Technology Series.

B. To create awareness of the Nuclear Technology Series and the curricula materials.

The tasks required for these objectives and how the tasks were completed are discussed under the heading that follows.

ACCOMPLISHMENT OF PROJECT TASKS

TASK A - Develop the approximately 72/74 unduplicated teaching/learning modules for the twelve technical specialty courses in the three technologies.

In completion of this task, twelve courses were prepared, containing a total of 74 new modules.

Prior to selection of authors the Associate Project Director met with the Project Advisory Committee's Subcommittee on Instrumentation and Control to redefine the titles and content of Courses No. 33 through 35 in this rapidly changing field. Copies of the courses for Radiation Protection and Nuclear Materials Handling also were sent for review to experts who were on the Committee and were designated by the Committee. Revisions to the module outlines were made by the TERC-SW staff and approved by the Committee at the December 7 and 8, 1978, meeting. Appendix A contains revised curriculum outlines, course descriptions, and module objectives for the three nuclear technologies. The courses and modules conform to the format previously established for Courses 1 through 16 of Contract No. 300760356.

Modules were developed by two methods:

A. Technical Resource Personnel (TRP) were located from industry and enlisted as consultants to provide detailed module outlines, reference materials, illustrations, and consultations with the TERC-SW in-house module author, who prepared the module draft. The draft was edited for technical accuracy and relevance by the TRPs and

revised before sending it out to reviewers.

A. TERC-SW staff enlisted technical experts from industry to write module drafts, which were edited by the project staff prior to preparation and review.

The second method provided higher quality, more cost effective materials, but resulted in delays in project milestones because these type of outside authors are extremely busy and many do not comply with agreed upon delivery schedules of module drafts.

TASK B - Secure critical reviews of all modules and revise the modules.

Draft copies of all modules in the three curricula were provided to nine appropriate/related educators and industry personnel (three copies to the OE Project Officer) for the purpose of critical review and obtaining detailed reaction on technical accuracy, scope of content, usability in postsecondary and industry programs, absence of sex stereotyping in text or illustrations, and adequacy in meeting industry needs and the needs of students. Table 3 contains a list of the module reviewers. All of these individuals reviewed more than one course, but none reviewed them all. The time spent in reviewing the modules, estimated at two hours per module, per person, represents over 1,000 person hours donated to the project by industry personnel.

TABLE 3. REVIEWERS OF NUCLEAR COURSE MATERIALS

Mr. James R. Bonannon, Jr., Carolina Power and Light Company
Mr. Robert E. Brooksbank, Oak Ridge National Laboratories
Dr. Tek Chand, Aiken Technical Education Center
Dr. Adrian Danl, Los Alamos Scientific Laboratory
Mr. Larry DeWitt, Columbia Basin College
Dr. David M. Ericson, Jr., Sandia Laboratory
Mr. Roger Felthous, General Electric Company
Mr. John J. Gammuto, Commonwealth Edison Company
Mr. George J. Gruber, Lakeshore Technical Institute
Dr. Arthur H. Guenther, U. S. Air Force Weapons Laboratory
Mr. Tom P. Hamrick, Oak Ridge National Laboratory
Mr. Donald J. Hosterman, Sandia Laboratory
Mr. Ronald L. Kathren, Battelle Pacific Northwest Laboratories
Mr. J. Carl Kee, Texas State Technical Institute
Dr. William E. Kreger, Nuclear Regulatory Commission
Mr. John P. Martelli, Rockwell-Hanford Operation
Mr. Richard J. Marzec, Duke Power Company
Dr. Larry McKay, Mississippi Gulf Coast Junior College
Mr. Stephen W. Mizia, EBASCO Services, Inc.
Dr. Raymond Morrison, Los Alamos Scientific Laboratory
Dr. Robert B. Neel, Nuclear Regulatory Commission
Dr. John Nehemias, Nuclear Regulatory Commission
Mr. Robert G. Profeta, General Electric Company
Mr. Leo Sain, Tennessass Valley Authority
Mr. Ron B. Seidel, Texas Utilities Generating Company
Mr. Paul Shoop, International Brotherhood of Electrical Workers
Mr. Richard Wright, Commonwealth Edison Company
Mr. Harold H. Young, U. S. Department of Energy

TASK C - Develop four program planning guides for postsecondary educational institution and industry based training programs for preparatory and upgrading purposes for each of the three curricula, plus one for the QA/QC technology.

The completed guides discuss in narrative form the decision-making areas relative to administrative and instructional/programmatic considerations as the basis for planning, implementing, operating, and evaluating both education institutional and industrial training programs. Each guide provides a suggested curriculum plan for the instructional staff and the organizational aspects of operating such a program. Each guide addresses such items as the following:

The occupational field.
Career opportunities.
Employment needs.
Knowledge and skill requirements.
Licensing (certification) requirements.
Faculty and students.
Instructional media and resources.
Facilities and equipment.
Program advisory committee.
Industry involvement and coordination.
The curriculum.
Course sequence and relationships.
Operating and evaluating the program.
Library and reference needs.
Appropriate appendices.

Refer to Appendix B for a Table of Contents from one of the guides.

Approximately fifty percent of the content of each guide was duplicative, or required a minimum of change from the NROT guide prepared in a previous project. This guide was suggested by the OE Project Officer for this project to be the basis for the development of the four guides and to follow for format and style. The NROT Guide was also updated by the contractor to reflect changes in course content, module titles, etc.

As with the modules, each guide was reviewed by nine technical experts, whose appropriate comments were made a part of the guide.

TASK D - Familiarize personnel in educational institutions, industry, and related organizations with the Nuclear Technology Series and the curricula materials.

TERC-SW receives many inquiries concerning its research capabilities and available educational materials in a wide range of occupational fields. Approximately 500 such inquiries over the last year have been sent the tract entitled Center for Occupational Research and Development. This promotional document includes a description of the nuclear program. Among those who received this tract were representatives from occupational education and the nuclear industry.

Specific requests for information about nuclear programs and materials were sent copies of the informational leaflets (described in Task E) and, upon specific request, draft copies of the curriculum guides. This activity is described under Task F. Copies of the informational leaflets were distributed at national or regional meetings (this activity is also described under Task F).

Another way in which TERC-SW has familiarized the nuclear community with the nuclear program is the advertisement in Figure 2. This advertisement appeared in the Nuclear News publication Buyer's Guide Eighty (Mid-March 1980, Vol. 23, No. 4, page 334). Nuclear News is published by the American Nuclear Society and reaches an audience of 15,000 monthly.

TASK E - Develop leaflets describing each of the three curricula (programs) and revise and update the leaflet and brochure developed in the two previous projects for use in informational activities and in responding to inquiries.

This work was completed in the production of the five new and revised leaflets — each of a different color but in the same format. One thousand copies of each leaflet were printed, and 50 copies of each were sent to the OE Project Officer. Excerpts from the information contained in each leaflet are included as Appendix C.

TASK F - Conduct a limited dissemination of the materials resulting from this project.

The completion of this task included the following:

1. Presentations, National Meetings and Publications
   a. For the National Energy Education, Business and Labor Conference held in Washington, DC, on January 15-17, 1979, Daniel

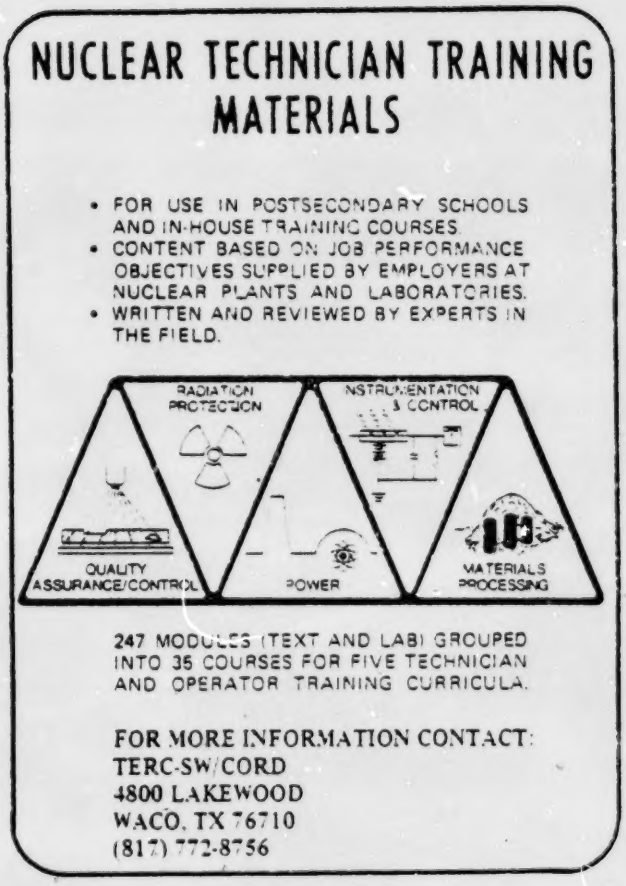
NUCLEAR TECHNICIAN TRAINING MATERIALS
• FOR USE IN POSTSECONDARY SCHOOLS AND IN-HOUSE TRAINING COURSES.
• CONTENT BASED ON JOB PERFORMANCE OBJECTIVES SUPPLIED BY EMPLOYERS AT NUCLEAR PLANTS AND LABORATORIES.
• WRITTEN AND REVIEWED BY EXPERTS IN THE FIELD.
RADIATION PROTECTION
INSTRUMENTATION & CONTROL
QUALITY ASSURANCE/CONTROL
POWER
MATERIALS PROCESSING
247 MODULES (TEXT AND LAB) GROUPED INTO 35 COURSES FOR FIVE TECHNICIAN AND OPERATOR TRAINING CURRICULA.
FOR MORE INFORMATION CONTACT:
TERC-SW/CORD
4800 LAKEWOOD
WACO, TX 76710
(817) 772-8756

Figure 2. TERC-SW advertisement for the nuclear program in the Nuclear News publication Buyer's Guide 1980.

M. Hull (Project Director) was appointed Nuclear Session Chairman. A Taskforce Report was prepared that served both as an agenda for the Nuclear Session and as a chronicle of the conference proceedings. The Report included information relative to the Nuclear Technical Workforce, its status, needs and training requirements; as well as a registry and synopses of papers. Papers were presented in the Nuclear Session by members of the National Steering Committee for Nuclear Technician Training with the following titles:

- Projection of Workforce Requirements for Nuclear Power Plants and Fuel Facilities - 1979-1984.
- Experience in Initial Staffing and Maintenance of a Workforce for Nuclear Plants:
  Utilities with Major Nuclear Commitments.
  Utilities with Modest Nuclear Commitments.
- Conducting a Local Needs Study to Justify Startup of an Institutional Training Program.
- Job Definitions/Task Inventories.
- Licensing and Certification.
- Commercial Training Programs.
- Institutional Training Programs.
- Employer Training Programs.

At this meeting, 200 copies of the five nuclear series brochures were distributed; 300 copies of the Nuclear Taskforce Report (which describes the instructional modules and includes a listing of schools that present nuclear training) also were distributed.

b. The Association Project Director (V. Woolf) presented a paper entitled "Public Training Programs and Instructional Materials for Nuclear Technicians and Operators — A Status Report," at the "Third Symposium for Training of Nuclear Facility Personnel" held in Gatlinburg, Tennessee, on April 29 - May 2, 1979. Copies of the Nuclear Reactor (Plant) Operator Trainee 16 courses, program planning guides, pamphlet, as well as Technology Series information request cards were displayed on a table and distributed to interested attendees.

c. During January 29-31, 1980, the Project Director, Daniel M. Hull, participated in a panel presentation to the American

Vocational Association meeting in Arlington, Virginia. The subject of this presentation was, "Energy Efficient Technologies and Materials."

d. On February 27, 1980, at the National Conference on Meeting Energy Workforce Needs in Washington, DC, the Project Director made a presentation entitled "Training to Assure Safe Operations in the Nuclear Industry." A copy of this presentation appears in the proceedings of this conference.

e. In March 1980, the Project Director presented the keynote speech on energy at the 17th National Conference on Technical Education in Columbus, Ohio.

f. On May 2, 1980, the Project Director made a presentation of "Nuclear Energy" at the Energy Education Symposium sponsored by Minnesota Department of Education, Red Wing School District #256, Minnesota Energy Agency, Mid-American Solar Energy Complex, Control Data Corporation, and McKnight Foundation.

g. The Project Director contributed information about nuclear instrumentation and control technicians and nuclear radiation protection technicians for an article written by Ms. Bonnie Bekken. This article is entitled "Focus on Technicians," and is to be published in the September 1980 issue of the Career World 2 magazine, a publication of Curriculum Innovations, Inc.

h. At the request of Mr. Harold H. Young of the U. S. Department of Energy, the Project Director prepared the U. S. A.'s Training Model for Nuclear Power Plant Workers for the International Atomic Energy Association's Guidebook on Manpower Development.

i. The Project Director conducted briefing sessions and supplied all project documents to Mr. E. L. Thomas, Manager of Education and Training for the Institute of Nuclear Power Operations (INPO), an organization recently formed by the electric utility industry to establish standards of excellence in nuclear power plant operation.

j. The Project Director conferred with the U. S. Senate Subcommittee on Three Mile Island.

2. Participation on National Committees

a. The Project Director and the Associate Project Director alter-

nately participated in the committee meetings of the Southern States Energy Board's project to study nuclear power plant siting (DOE Nuclear Energy Center Program, Subcontract 7336 for Oak Ridge National Laboratory). Project Director, Mr. Dan Hull, is the Committee's representative for Education and Training.

b. The Project Director participated on the ASTM C-26.08 Subcommittee on Training and Certification Criteria for the Nuclear Fuel Cycle.

3. Mailings of Information

Early in the project, TERC-SW sent 963 visibility letters to postsecondary educational institutions. Approximately 200 replies and requests for further information were received, and all were answered with the appropriate data.

4. Sales of Modules

Table 4 lists utilities, schools, and individuals who have ordered materials from the nuclear series. A total of 8,577 nuclear modules were distributed by TERC-SW in 1979 and 1980. The figure 8,577 is broken down as follows:

- Total 1979 distribution — 3,407.
- Total 1980 distribution — 5,170.
- Total distribution to schools — 5,000.
- Total distribution to utility industry — 3,500.
- Total distribution to individuals — 77.

Increased distribution is anticipated; and efforts are being made to increase sales.

TASK G - Develop plans for and conduct a national workshop providing dissemination and diffusion information and activities on the Nuclear Technology Series.

The workshop was conducted for the purpose of familiarizing attendees with the Nuclear Technology Series Curricula, diffusion activities, the course and module materials, and the program planning guides for the five curricula. Denver, Colorado, was chosen as the site of the workshop because of its central locality. The workshop was held in the Plaza Cosmopolitan Hotel.

Objectives of the workshop were as follows:

TABLE 4. UTILITIES, SCHOOLS, AND INDIVIDUALS
WHO HAVE ORDERED NUCLEAR-SERIES MATERIALS

Aiken Technical College	Pacific Gas and Electric Company
Audio-Visual Services	Pacific Radiation Corporation
Bureau of Radiological Health, Rockville, Maryland	Public Services Company of Oklahoma
Chattanooga State Technical College	Rochester Gas and Electric Corporation
Clemson University	Rockwell-Hanford Operations
Commonwealth Edison Company	Siena College
Dallas Independent School District	Southern California Electric and Gas Company
Denmark Technical Education Center	Spitalnik, J. (an individual request)
Duke Power Company	Spokane Community College
Duke Power Company, Quality-Assurance Department	State Technical Institute at Knoxville, Tennessee
Florence-Darlington Technical College	Tampa Electric Power Company
Forman, Dr. James D.	Tennessee Valley Authority
Georgia Power and Light Company	Terra Technical College
Industry Education Center, Phoenix, Arizona	Texas State Technical Institute, Harlingen Campus
Lawrence Livermore Laboratories	Texas State Technical Institute Waco Campus
Lay, V. (an individual request)	Texas Utilities Generating Company
Louisiana Power and Light Company	Thaden, G. (an individual request)
Maxwell, David	Union Electric Company
Mill-Power Supply Company	Universidad Simon Bolivar
Mississippi Gulf Coast Junior College	University of Maryland
Niagara Mohawk Power Company	University of Missouri - Rolla
Northern Area Special Purpose School	University of Toledo
Nuclear Technology Club, Texas State Technical Institute	Upton, Allen D. (an individual request)
Numanco, Inc. (Mr. Robert Pickett)	Washington Public Power Supply
	Western Kentucky University
	ZIA Company, Los Alamos, New Mexico

- Explain anticipated growth of the nuclear power industry and the need for well prepared technicians.
- Describe the five job categories of nuclear technicians and the tasks each performs.
- Present model curricula and nuclear technology series instructional materials, and explain how they can be adapted to meet local employer and school needs.
- Encourage schools and employers to implement courses and programs for training nuclear technicians.

During the workshop, a different nuclear expert described the job requirements of each of the five nuclear job categories. Following each of these speeches, a TERC-SW staff member discussed how the materials in the nuclear series meet the training requirements of the job categories. Table 5 lists the various speakers and topics.

Each person in attendance received (1) the five nuclear Suggested Program Planning Guides, each of which is approximately 75 pages in length, and (2) two selected nuclear modules (Modules 11-4 and 10-1).

Four persons from each State and Territory having responsibilities for postsecondary program planning and development were invited, such as: State Department technical/postsecondary supervisors; and directors of postsecondary institution technical programs. In addition, the six Center Directors of the National Network for Curriculum Coordination were invited, along with interested training directors or their representatives from electric utility companies. The Department of Education Project Officer, Richard Eason, was sent 2500 brochures announcing the workshop; a copy of the brochure is in Appendix D. In all, nearly 5,000 of these promotional brochures were sent to prospective attendees.

As the brochure indicates, the nuclear workshop was held the day following a workshop, also sponsored by TERC-SW/CORD, on the coal-fired power plant curriculum being developed under sponsorship by the Electric Power Research Institute. Most of those in attendance stayed for both sessions. This indicates that, of the 88 who attended, a number of individuals were introduced to the nuclear program who might not have been had the workshops been held at different places and times.

Foundations were laid for added cooperation between the nuclear industry and educational institutions. Industry is feeling the need for more and more qualified, trained technicians, which the schools will be able to provide, in large measure, through adaptation of the nuclear

TABLE 5. PRESENTATIONS AT THE NATIONAL NUCLEAR WORKSHOP, DENVER, AUGUST 15, 1980

SUBJECT	SPEAKER
Nuclear Reactor Operator Job Requirements	Mr. John Gammuto, Commonwealth Edison
Nuclear Reactor Operator Trainee Curriculum	Mr. Daniel M. Hull TERC-SW
Instrumentation and Control Technician Job Requirements	Mr. Robert G. Profeta General Electric Company
Instrumentation and Control Technician Curriculum	Mr. Ellis Lindsey TERC-SW
Radiation Protection Technician Job Requirements	Dr. Bette Murphy, Battelle Pacific Northwest Laboratories
Radiation Protection Technician Curriculum	Mr. J. Carl Kee, Texas State Technical Institute
Modularized Instructional Materials	Mr. Daniel M. Hull TERC-SW
QA/QC Technician Job Requirements	Ms. Dione Krobetzky, EBASCO Services, Inc.
QA/QC Technician Curriculum	Mr. Daniel M. Hull TERC-SW
Nuclear Materials Processing Technician Job Requirements	Mr. Donald J. Hosterman, Sandia Laboratory
Nuclear Materials Processing Technician Curriculum	Mr. Ellis Lindsey, TERC-SW
Wrapup and Additional Input from Attendees	Mr. Daniel M. Hull, Moderator

NOTE: In addition to the speeches, informal sessions were conducted with representatives of the utilities and schools. These sessions produced added interest among the attendees for cooperative efforts between the two groups.

programs. There are now approximately 70 commercial nuclear power plants on-line in America; however, the nearly 200 others now under construction or nearing construction will require enormous numbers of technicians.

Such technicians will be trained not only in schools, but also within the nuclear industry itself. The Nuclear Technology Series is ideal for in-house training programs. In some cases, schools and industry are working together to obtain student credit for completing in-house programs.

Following the nuclear national workshop, a questionnaire was given each attendee. The answers from the 33 attendees who responded are tabulated in Table 6. Each individual provided in the answers an evaluation of the workshop. Response to the workshop was excellent.

As indicated by the tabulations in Table 6, the attendees appreciated most (1) the Program Planning Guides, (2) the speeches and job needs and course materials, and (3) the interaction with others — all in that order.

TASK H - Contract modification to prepare 35 Course Indexes and a Master Index for the entire Nuclear Technology Series.

At the request of members of the National Steering Committee for Nuclear Technician Training, TERC-SW submitted to the Office of Education a proposal for preparation of an Index for each of the 35 Nuclear Technology Series courses and one Master Index to include listings from all 35 courses. This work, which was subsequently funded, extended the contract completion date and allowed the National Dissemination Workshop to be delayed until summer. Steering Committee members had indicated that the original workshop schedule was too soon after the accident at Three Mile Island and might not be well attended. A five-month delay was thought to be helpful.

Each course index averages four pages of reduced, two-column type with approximately 350 entries. The Master Index is 80 pages long, and bound as a separate document. The format for the indexes was based on the University of Chicago's Manual of Style (12th edition).

In addition to providing the common benefits and advantages associated with course indexes, the indexes are intended to accomplish the following:

TABLE 6. ATTENDEES' EVALUATION OF NATIONAL WORKSHOP.

QUESTION NO.	QUESTIONS AND TABULATED ANSWERS (Numbers in parentheses indicate the number of individuals who responded.)
1	Question: "What is your job responsibility, and who is your employer?" Answer: Of the 33 individuals who responded, 17 were from the power utilities industry; and 16, from education.
2	Question: "What was your objective in attending this workshop?" Answer: • To obtain materials and learn about new programs (12). • To determine industry needs for training (9). • To determine methods of meeting training needs (6). • To establish contacts (3).
3	Question: "How well did the workshop meet your needs?" Answer: Very well (26); adequately (5); partially (1).
4	Question: "Which part of the workshop was most beneficial to you?" Answer: Most cited the materials; others, the lectures; and some, interaction between industrial and educational representatives.
5	Question: "Which part of the workshop was least beneficial to you?" Answer: • All were beneficial (9). • Materials should have been distributed at one time (2). • Job descriptions (3). • Various subject areas outside the attendee's interest (7).
6	Question: "Which of the distributed materials will be of assistance to you? How?" Answer: • Program Planning Guides (25). • Sample modules (2). • All (2).
7	Question: "Please comment on the logistics of the workshop – location, date, arrangements, schedule, etc." Answer: • Excellent (16). • Adequate (5). • Hold several regional workshops instead of one national workshop (4). • Newer hotel closer to airport (4). • Rearrange important points earlier in workshop (1). • Need more conversation and visiting time (2).
8	Question: "How do you feel about cooperative arrangements between utilities and institutions for providing this type of training?" (Discuss both pre-employment and employee training.) Answer: • Excellent idea (25). • Pre-employment training only (5). • Reservations (1). • Schools only (1). • None except in isolated instances (1). NOTE: Refer to text for comments of attendees on Question 8.

- Facilitate inclusion of Nuclear Technology Series courses and modules into access-and-retrieval systems, such as ERIC.
- Simplify module selection for specialized curricula formulation. A curriculum designer quickly could identify and review specific content.
- Aid instructors and students to access the Nuclear Technology Series for specific study and definitions during the conduct of the course and after employment.
- Enable the Nuclear Technology Series to be used by technical organizations and libraries as valuable resource and reference documents.

As a direct consequence of recent experiences (e.g., Three Mile Island), training for nuclear power plant operators and technicians is becoming much more stringent, as well as more formalized and sophisticated. The USOE-sponsored Nuclear Technology Series, because of these new developments, bodes to become a major tool in this intensified training requirement. Their greater importance in pre-employment and post-employment training programs suggests the need for maximum utility — the intent of the index effort.

PROJECT ADVISORY COMMITTEE

Curriculum development in an emerging field such as nuclear technology cannot successfully be accomplished by a school or an educational research organization like TERC-SW without the enthusiastic support of working experts from all areas of the industry. The National Steering Committee for Nuclear Technician Training was established in 1974 by TERC-SW's Project Director (the Committee's chairman) and has been actively supporting each of the sponsored project phases that TERC-SW has conducted.

The Committee's membership (listed in Table 7) is composed of representatives from the nuclear utilities, fuel processing/reprocessing organizations, a labor union, U. S. Department of Energy and DOE contractor laboratories, U. S. Nuclear Regulatory Commission, schools, U. S. Air Force, and other relevant organizations. The members of this Committee serve without compensation and their travel to meeting is paid for by their employers (except two members who paid their own travel).

The Committee met together twice during the project:

A. December 7 and 8, 1978, in Waco, Texas, to review the project activities and curricula, to approve changes in module titles and content, and to recommend module authors and reviewers.

B. August 13, 1980, in Denver, Colorado, to review project accomplishments, consider changes to the curricula as a result of the lessons learned from the Three Mile Island nuclear incident, and to plan for their contributions to the National Workshop held on August 15, 1980.

Most of the work of the Committee was accomplished by mail or phone, and consisted of:

A. Identification of module authors and reviewers.

B. Clarification of technical questions related to the curricula, module content, or laboratory equipment.

C. Review of modules.

D. Assisting local schools in implementing programs and/or using materials.

E. Describing the project and materials to colleagues at work or in meetings.

F. Providing opportunities for the project staff to speak about the

TABLE 7. MEMBERSHIP LIST OF NATIONAL STEERING COMMITTEE FOR NUCLEAR TECHNICIAN TRAINING.

Mr. Daniel M. Hull, Chairman
Technical Education Research Center – Southwest

Mr. James R. Bohannon, Jr.
Carolina Power and Light Company

Mr. Gerald W. Bowdren
Public Service Electric and Gas Company

Mr. Robert E. Brooksbank
Oak Ridge National Laboratories

Ms. Betty Byers
South Bend Medical Foundation, Inc.

Dr. Tek Chand
Aiken Technical Education Center

Dr. Adrian Dahl
Los Alamos Scientific Laboratory

Mr. Larry DeWitt
Columbia Basin College

Dr. David M. Ericson, Jr.
Sandia Laboratory

Mr. W. Scott Fellows
Southern States Energy Board

Mr. Roger Felthous
General Electric Company

Mr. John J. Gammuto
Commonwealth Edison Company

Mr. George J. Gruber
Lakeshore Technical Institute

Dr. Arthur H. Guenther
U. S. Air Force Weapons Laboratory

Mr. Tom P. Hamrick
Oak Ridge National Laboratory

Mr. Donald J. Hosterman
Sandia Laboratory

Dr. R. Joe Johnson
Tennessee Valley Authority

Mr. Ronald L. Kathren
Battelle Pacific Northwest Laboratories

Mr. J. Carl Kee
Texas State Technical Institute

Dr. Larry McKay
Mississippi Gulf Coast Junior College

Mr. Stephen W. Mizia
EBASCO Services, Inc.

Dr. Robert B. Neel
U. S. Nuclear Regulatory Commission

Dr. John Nehemias
U. S. Nuclear Regulatory Commission

Dr. Maurice W. Roney
Texas State Technical Institute

Mr. Gordon K. Rusch
Argonne Laboratories

Mr. Ron B. Seidel
Texas Utilities Generating Company

Mr. Paul Shoop
International Brotherhood of Electrical Workers

Mr. M. S. "Terry" Terrass
Washington Public Power Supply System

Mr. Harold H. Young
U. S. Department of Energy

Ex Officio Member:
Dr. Walter J. Brooking
Project Monitor
U. S. Office of Education

materials at national meetings.

G. Making presentations at the National Workshop.

The time donated to the project by the thirty members of this Committee is estimated to average about 30 hours per person, or 900 hours, not including module reviews. The travel to committee meetings and the workshop, donated by the employers of these committee members, is estimated to have cost approximately $25,000.00.

RECOMMENDATIONS

1. During the later period of this project, the future growth of nuclear power in the United States has become unclear. Obviously, public institutions are reluctant to commit portions of their very tight budgets to initiating new programs in nuclear technology until the future prospects for growth in nuclear power are more positive. Dissemination and use of the instructional materials is presently centered in established programs in institutions and training programs sponsored by employers.

   If in the future this country endorses nuclear power and encourages its growth, then another project effort should be considered to assist and encourage postsecondary institutions to initiate new programs in one or more of the areas of nuclear technology.

2. The instructional materials should be reviewed in four years and an evaluation should be made as to whether updating them is needed.

3. A study should be made on the cooperative relationships possible between electric power utilities and schools. The study should not be confined to nuclear plants but should be extended to the training of workers at all types of electrical generating stations.

   Until recent times, the electric utility has relied very little on public, postsecondary institutions to provide training for its plant operators and technicians (neither pre-employment training, nor for updating or upgrading). However, this industry has experienced immense growth in recent years and is projecting an even larger growth in the decade of the 1980s. Furthermore, the complexities of new plants (coal-fired plants as well as nuclear ones) require a workforce with more and better technical training.

   Existing employment patterns involving on-the-job and apprenticeship type training are proving to be inadequate and very expensive. Utility company employers are showing an increased interest in utilizing public institutions and their technician graduates; however, effective, cooperative relationships between utilities and schools will require changes in employment practices, job progression dependent upon training to achieve proficiency in job tasks, and entry-level salaries that are competitive with other industries competing to hire technical school graduates.

APPENDIX A

CURRICULUM OUTLINES, COURSE DESCRIPTIONS, AND MODULE OBJECTIVES FOR NUCLEAR RADIATION PROTECTION, NUCLEAR INSTRUMENTATION AND CONTROL, AND NUCLEAR MATERIALS PROCESSING TECHNOLOGIES

THE NUCLEAR RADIATION PROTECTION TECHNICIAN CURRICULUM

COURSES

The Radiation Protection Technician curriculum incorporates learning objectives and supporting objectives based upon related knowledge, as well as upon the tasks the technician is expected to perform in industry today.

Although the curriculum design specifically relates to training Radiation Protection Technicians, every course and every module invites multiple application. An example Radiation Protection Technician curriculum is provided in Table 8.

TABLE 8. RADIATION PROTECTION TECHNICIAN CURRICULUM.

	Periods/Week		
	Class	Lab	Total
First Quarter			
Introduction to Nuclear Technology	2	3	5
* Radiation Physics (Course 1)	3	3	6
Mathematics I	3	2	5
Introduction to Electricity & Electronics	3	3	6
Introduction to Technical Communications	2	2	4
Elective	1	0	1
	14	13	27
Second Quarter			
* Radiation Detection & Measurement (Course 11)	3	4	7
Chemistry I	3	6	9
* Radiation Protection I (Course 2)	3	3	6
Mathematics II	3	2	5
	12	15	27
Third Quarter			
* Introduction to Quality Assurance/Quality Control (Course 14)	2	3	5
* Introduction to Nuclear Systems (Course 5)	3	4	7
Introduction to Radiation Biology	3	3	6
Chemistry II	2	6	8
	10	16	26
Fourth Quarter			
Technical Writing	2	3	5
* Radiation Protection II (Course 17)	3	4	7
* Radiological Emergencies (Course 18)	3	4	7
* Power Plant Chemistry (Course 13)	2	6	8
	10	17	27
Fifth Quarter			
* Radiation Shielding (Course 19)	3	3	6
* Radiation Monitoring Techniques (Course 20)	3	4	7
* Radioactive Materials Disposal and Management (Course 21)	3	4	7
Elective	3	3	6
	12	14	26
Sixth Quarter			
Special Projects	4	8	12
* Advanced Radionuclide Analysis (Course 22)	3	3	6
Occupational Safety and Health	3	3	6
Elective	3	3	6
	13	17	30

* Technical specialty courses for which instructional modules have been developed.

COURSE DESCRIPTIONS

Each course in the curriculum is described to indicate both its content and its relevance to the overall program.

FIRST QUARTER

Introduction to Nuclear Technology.
An introduction to the principles and applications of nuclear energy. Student is introduced to basic principles involved in nuclear radiation, nuclear sources, reactors and fuel cycles. Essential features of a nuclear power plant are discussed. Student also learns how radionuclides and radiation have application in industry and medicine. Nuclear safety will be emphasized and radiation effects evaluated. Lab sessions will include field trips, films and guest speakers. (Note: Materials for this course should be obtained from nuclear utility public relations offices.)

*Radiation Physics.
An introductory course in basic concepts of nuclear radiation. Main topics covered include atomic and nuclear structure, radioactivity and interaction of radiation with matter. Student is introduced to basic radiation and measuring instruments, including Geiger-Müeller counters and personnel monitoring devices.

Mathematics I.
A course in algebra, geometry and introductory trigonometry. Includes ratios, linear equations, plotting, reading and interpreting graphs and sinusoids. Math labs are problem sessions, preferably conducted by the nuclear faculty.

Fundamentals of Electricity and Electronics.
A study of basic principles of direct current and alternating current, series and parallel circuit analyses utilizing Ohm's and Watt's laws, basic motors, generators and relays.

Introduction to Technical Communications.
An introduction to the nature of communication skills and thinking processes with practical exercises in writing, reading, speaking, spelling and vocabulary as related to technical areas. Emphasis on writing, making reports and utilizing the use of a memoranda.

Elective.

SECOND QUARTER

*Radiation Detection and Measurement.
A course in principles and methods used to detect and measure radiation, with emphasis on ionization and scintillation detectors. Statistics of counting will be introduced. Properties of α, β and γ will be studied.

Chemistry I.
Basic chemical principles are introduced, using modern laboratory techniques to demonstrate concepts, including atomic structure of matter, formulae, composition and bonding, the electrical nature of matter, acids, bases, oxides, salts and salt solutions.

*Radiation Protection I.
An introductory course to familiarize student with the field of radiation protection, the art and science of protecting human beings from injury by radiation. Specific topics include dose and exposure measurements and units, biological effects of radiation, Federal Regulations of exposures and internal exposure evaluations.

Mathematics II.
A continuation of Mathematics I; algebra includes logarithms to base 10 and base e and exponentials; geometry and trigonometry emphasizing slopes, rates of change and solutions of equations and problems with transcendental functions.

THIRD QUARTER

*Introduction to Quality Assurance and Quality Control.
An introductory course in quality assurance and quality control; including such topics as history and purpose of quality control, terms and definitions, codes and standards, publications and quality assurance/quality control procedures.

*Introduction to Nuclear Systems.
This course will include a basic understanding of all major components of the reactor core, pressure vessel, shields, and primary cooling water systems. Differences between PWR's and BWR's will be discussed. The basic nuclear fuel cycle also will be discussed.

Introduction to Radiation Biology.
A study of basic biology and radiation damage in biological systems.

Chemistry II.
A continuation of Chemistry I, with more emphasis placed on theory and methods of solution.

*Technical specialty courses.

FOURTH QUARTER

Technical Writing.
A study of effective ways of presenting information with emphasis on the use of logs, keeping of records and notebooks, use of graphs, drawings and sketches, and various types of reports.

*Radiation Protection II.
This course is a continuation of Radiation Protection I and includes calibration techniques for film badges and TLD's; assessment of dose rates obtained from film badges and TLD's; bioassay techniques; and demonstrates proper dose record keeping methods.

*Radiological Emergencies.
This course describes principles of emergency procedures, types of accidents, classifications (including causes and how they are handled), historical cases and planning; detailed procedures for handling a radiological emergency in the laboratory are given. Covering hypothetical conditions; actual exercises for handling radioactive spills in the radiochemistry laboratory; and demonstration of emergency equipment are included.

*Power Plant Chemistry.
A course designed to introduce student to chemistry of fossil and nuclear power plants, including water properties, water treatment and purification, and primary coolant chemistry programs. Gaseous and liquid radioactive waste handling are discussed.

FIFTH QUARTER

*Radiation Shielding.
This course describes the principles of radiation shielding, radiation attenuation, exponential absorption theory, cross-section and absorption coefficients, build-up factors, scattering and material effects; dose reduction of a shield using rule-of-thumb calculations are presented, material, geometry, thickness, radiation type and energy; measured radiation levels in a nearby radiation facility (such as medical x-ray facility) for determination of actual attenuation and scattering effects.

*Radiation Monitoring Techniques.
Description, practices, and familiarity with sample preparation techniques and air, water and biota monitoring techniques for environmental monitoring (both on-site and off-site) of radiation are presented.

*Radioactive Materials Disposal and Management.
Procedures for monitoring and disposal of radioactive materials to conform to DOE, NRC, and DOT regulations; and monitoring and disposition of a given radioactive material sample to conform to the above regulations are described.

Elective.

SIXTH QUARTER

Special Projects.
This course is designed to allow the student to achieve a higher degree of specialization than would otherwise be possible. Work must be on a project closely related to student's chosen specialty. This course should be taken in the last school quarter.

*Advanced Radionuclide Analysis.
This course is designed to allow the student to determine the identity and quantity of an unknown radionuclide from radiation type, energy, half-life and chemical analysis.

Occupational Safety and Health.
General introduction to general occupational safety and health. Specific topics include fire control, general safety and rules and regulations, protective clothing, breathing apparatus, toxicology, and administration of overall safety program.

Elective.

TECHNICAL SPECIALTY COURSES AND MODULE TITLES AND DESCRIPTIONS — RADIATION PROTECTION

The courses developed specifically for the Radiation Protection curriculum are courses 17 through 22. A description of these courses and the modules in each course follows. The suggested Radiation Protection curriculum includes courses 1, 2, 5, 11, 13, and 14 from the curriculum of the Nuclear Reactor Operator (Trainee) program under separate Contract No. 300760356.

COURSE 17, RADIATION PROTECTION II.

Module 17-1, "Film Dosimetry."

Upon completion of this module, the student should be able to use film badges for determination of beta, gamma, x-ray and neutron doses, evaluate the exposure results, describe techniques used to evaluate, calibrate and develop films.

Module 17-2, "Thermoluminescent Dosimetry (TLD)."

Upon completion of this module, the student should be able to calibrate and process TLD's for beta, gamma, x-ray and neutron doses.

Module 17-3, "Radiation Dose Assessment."

Upon completion of this module, the student should be able to assess the external radiation dose read by film badges and TLD's and relate to recommended exposure dose limits.

Module 17-4, "Internal Dose Assessment."

Upon completion of this module, the student should be able to describe how radioactive materials enter the body and how they are metabolized there. The student should be able to perform internal dose calculations.

Module 17-5, "Bioassay Techniques and Recordkeeping for Radiation Protection."

Upon completion of this module, the student should be able to describe procedures and equipment used, how to determine a representative sample, how to choose the correct equipment, how to choose the correct sample preparation technique, and how to analyze the result for bioassay monitoring; and perform an actual bioassay, including the choosing of the appropriate equipment and sample preparation technique, and analysis of the sample to determine the concentration. The student should be able to described the various types of radiation records kept in a nuclear facility; explain the reasons (including legal) why these records must be kept; and devise a recordkeeping system for a small radiation laboratory, including the types and frequency of data collection.

COURSE 18, RADIOLOGICAL EMERGENCIES.

Module 18-1, "General Procedures for Radiological Emergencies."

Upon completion of this module, the student should be able to describe principles of emergency procedures, general classifications (including causes and how they are handled), types of accidents, and historical cases.

Module 18-2, "Emergency Equipment for Nuclear Facilities."

Upon completion of this module, the student should be able to demonstrate the use of, and to give the applicability of, the following emergency equipment: rescue equipment, protective clothing, breathing apparatus, and emergency monitoring instruments.

Module 18-3, "Surface Contamination — Decontamination."

Upon completion of this module, the student should be able to describe types and characteristics of surface contamination, control and evaluation of contamination, effects of surface finishes, principles and objectives of decontamination, and procedures and equipment for decontamination.

Module 18-4, "Criticality Control."

Upon completion of this module, the student should be able to discuss general principles and theoretical aspects, safe designs, safety instrumentation, and operational requirements for criticality control; and discuss practical aspects of criticality control in research and power reactors, fuel production and processing, and transportation and storage of fissionable materials.

Module 18-5, "Control of Radiological Hazards."

Upon completion of this module, the student should be able to discuss methods by which radioactivity that results from radiological emergencies can enter the environment, through atmospheric dispersion and disposition, inland and sea waters, geological structures, and other media.

Module 18-6, "Emergency Planning for Nuclear Facilities."

Upon completion of this module, the student should be able to describe the overall emergency planning of a nuclear facility, including actions and responsibilities of various groups, emergency equipment, emergency drills, post-accident activities and cleanups, and exposure assessment.

Module 18-7, "Emergency Drills for Nuclear Facilities."

Upon completion of this module, the student should be able to participate in an emergency drill of a simulated, large radioactivity release in a nuclear facility or radiation laboratory and to demonstrate proper and/or correct knowledge of the following: evaluation and assessment, evacuation, use of emergency equipment, equipment shutdown, decontamination, and re-entry.

COURSE 19, RADIATION SHIELDING.

Module 19-1, "General Effect of Radiation Attenuation."

Upon completion of this module, the student should be able to describe the effect of radiation type, energy, scattering, and shield material on radiation attenuation.

Module 19-2, "Beta and Alpha Particle Attenuation."

Upon completion of this module, the student should be able to describe the effect of energy, scattering, and shield material on beta and alpha radiation attenuation; and to calculate the attenuation of alpha and beta radiation through a shield, given the radiation type, energy, shield dimensions, and material.

Module 19-3, "Neutron Attenuation."

Upon completion of this module, the student should be able to describe the effect of the energy, scattering, and shield material on neutron radiation attenuation; to calculate the attenuation of a neutron beam through a shield, given the energy, shield dimensions, and material; to describe the meaning of scattering and absorption cross section, both microscopic and macroscopic; and to calculate the macroscopic cross section, given the absorbing material and neutron energy.

Module 19-4, "Gamma Attenuation."

Upon completion of this module, the student should be able to describe the effect of energy, scattering, and shield material on gamma-radiation attenuation; and to calculate the attenuation of gamma radiation through a shield, given the energy, shield dimensions, and material.

Module 19-5, "Background Radiation Reduction Techniques."

Upon completion of this module, the student should be able to discuss the reasons for, and precautions necessary to, the accurate performance of low-background measurements.

Module 19-6, "Backscattering and Wall Scattering of Radiation."

Upon completion of this module, the student should be able to describe the effect of backscattering and wall scattering on beta, gamma, and neutron radiation; to measure radiation levels in a nearby radiation facility (such as a medical x-ray facility); to determine actual attenuation and scattering effects.

COURSE 20, RADIATION MONITORING TECHNIQUES.

Module 20-1, "Radiation Sample Preparation — Liquid."

Upon completion of this module, the student should be able to describe various methods for preparation and counting of a liquid sample for radioactive measurements; practice preparing and counting the samples; and obtain familiarity with micro-measuring techniques and with remote handling techniques.

Module 20-2, "Radiation Sample Preparation — Solid."

Upon completion of this module, the student should be able to describe various methods for preparing and counting a solid sample for radioactive measurements; practice preparing and counting the samples, and obtain familiarity with micro-measuring techniques and with remote handling techniques.

Module 20-3, "Air Monitoring Techniques — Particulate."

Upon completion of this module, the student should be able to describe procedures and equipment used to gather a representative sample, how to choose a sampler, and how to analyze a filter sample for monitoring air containing particulate radioactivity; and perform such actual air monitoring, including choosing the appropriate samplers, assuring a representative sample and analyzing the sample to determine the atmospheric concentration.

Module 20-4, "Air Monitoring Techniques — Gaseous."

Upon completion of this module, the student should be able to describe procedures and equipment used, how to gather a representative sample, how to choose a sampler, and how to analyze a filter sample for monitoring air containing gaseous radioactivity; and perform such actual air monitoring, including choosing the appropriate samplers, assuring a representative sample and analyzing the sample to determine the atmospheric concentration.

Module 20-5, "Water Monitoring Techniques — Dissolved Solids."

Upon completion of this module, the student should be able to described procedures and equipment used, how to gather a representative sample, how to choose the correct equipment, how to choose the correct sample preparation technique, and how to analyze the result for the monitoring of water that contains dissolved solid radioactivity; and perform such an actual monitoring, including the choice of appropriate equipment and sample preparation techniques and analysis of the sample to determine the concentration.

Module 20-6, "Water Monitoring Techniques — Suspended Solids."

Upon completion of this module, the student should be able to describe procedures and equipment used, how to gather a representative sample, how to choose the correct equipment, how to choose the correct sample preparation technique, and how to analyze the result for monitoring water that contains suspended solid radioactivity; and perform such an actual monitoring, including the choice of the appropriate equipment and sample preparation technique and analysis of the sample to determine the concentration.

Module 20-7, "Radiation Monitoring of Biological Samples."

Upon completion of this module, the student should be able to describe procedures and equipment used, how to gather a representative sample, how to choose the correct equipment, how to choose the correct sample preparation technique, and how to analyze the result of the monitoring of biota (fish, animals, soil, and plants); and perform such actual monitoring, including the choice of the appropriate equipment and sample preparation technique and analysis of the sample to determine the concentration.

COURSE 21, RADIOACTIVE MATERIALS DISPOSAL AND MANAGEMENT.

Module 21-1, "Waste Disposal Procedures."

Upon completion of this module, the student should be able to discuss sources of radioactive waste in a nuclear power plant; to describe procedures for disposing radioactive materials from a laboratory and from a nuclear power plant; and to cite procedures for disposing of a given radioactive material in the laboratory.

Module 21-2, "Routine Sampling of Radioactive Waste."

Upon completion of this module, the student should be able to describe radioactive waste processing and disposal systems in nuclear facilities and the hazards associated therewith; to draw a typical schematic diagram of a system, showing sampling locations; and to describe the techniques used to sample and analyze the systems.

Module 21-3, "Waste Disposal Regulations."

Upon completion of this module, the student should be able to discuss the limits placed on discharge of radioactive waste by DOE, NRC, and various state and local agencies. The student also should be able to classify the various types of waste and to describe methods used in the analysis of each.

Module 21-4, "Measurement of External Radioactive Contamination."

Upon completion of this module, the student should be able to describe the necessary steps in taking a sample for the testing of the exterior surface of a shipping or storage container of nuclear material.

Module 21-5, "Regulations for Transporting Radioactive Materials."

Upon completion of this module, the student should be able to discuss the DOT requirements for shipping radioactive materials; to discuss types of accidents that could occur during shipping and the consequences of each; and to discuss steps that would be taken following such accidents.

Module 21-6, "Packaging and Monitoring of Radioactive Materials for Shipment."

Upon completion of this module, the student should be able to describe procedures for monitoring shipments of radioactive material sent off-site, including compliance with NRC and state regulations.

Module 21-7, "Leak Tests of Sealed Radioactive Sources."

Upon completion of this module, the student should be able to test the integrity of a sealed source and to discuss the process used to seal sources.

COURSE 22, ADVANCED RADIONUCLIDE ANALYSIS.

Module 22-1, "Survey of Methods Used in Radionuclide Analysis (Sample Collection and Analysis)."

Upon completion of this module, the student should be able to describe briefly the various techniques and equipment used to identify unknown radionuclides and how to choose the correct technique and equipment for a given unknown.

Module 22-2, "Gamma Spectrometry."

Upon completion of this module, the student should be able to described gamma spectrometry techniques for the identification of unknown radionuclides and to perform a radionuclide determination by gamma spectrometry.

Module 22-3, "Alpha Spectrometry."

Upon completion of this module, the student should be able to describe alpha spectrometry techniques for the identification of unknown radionuclides and to perform a radionuclide determination by using alpha spectrometry.

Module 22-4, "Beta Spectrometry."

Upon completion of this module, the student should be able to describe beta spectrometry techniques for the identification of unknown radionuclides and to perform a radionuclide determination by beta spectrometry.

Module 22-5, "Radiochemical Methods of Analysis by Liquid Scintillation Counting."

Upon completion of this module, the student should be able to describe several radiochemical methods, used either alone or in conjunction with a radiation-spectrometry method, to determine the identity of radionuclides, and to perform an actual radionuclide determination by a radiochemical method.

Module 22-6, "Neutron Activation Analysis."

Upon completion of this module, the student should be able to describe procedures for neutron activation analysis, and to perform an actual neutron activation analysis.

Module 22-7, "Determination of Specific Nuclides."

Upon completion of this module, the student should be able to determine the identity of unknown radionuclides by use of the appropriate procedures and equipment.

THE NUCLEAR MATERIALS PROCESSING TECHNICIAN CURRICULUM

COURSES

The Nuclear Materials Processing Technician curriculum incorporates learning objectives and supporting objectives based upon related knowledge, as well as the tasks the technician is expected to perform in industry today.

Although the curriculum design specifically relates to the training of Nuclear Materials Processing Technicians, every course and every module invites multiple application. An example of the curriculum is provided in Table 9.

TABLE 9. NUCLEAR MATERIALS PROCESSING TECHNICIAN CURRICULUM.

	Periods/Week		
	Class	Lab	Total
First Quarter			
Introduction to Nuclear Technology	2	3	5
*Radiation Physics (Course 1)	3	3	6
Mathematics I	3	2	5
Fundamentals of Electricity and Electronics	3	3	6
Introduction to Technical Communications	2	2	4
Elective	1	0	1
	14	13	27
Second Quarter			
*Radiation Detection and Measurement (Course 11)	3	4	7
Chemistry I	3	6	9
*Radiation Protection I (Course 2)	3	3	6
Mathematics II	3	2	5
	12	15	27
Third Quarter			
Blueprint Reading	1	3	4
*Introduction to Quality Assurance/Quality Control (Course 14)	2	3	5
*Principles of Process Instrumentation (Course 3)	3	3	6
Chemistry II	2	6	8
*Metrology (Course 27)	1	3	4
Elective	3	0	3
	12	18	30
Fourth Quarter			
Technical Writing	2	3	5
*Metallurgy and Metals Properties (Course 15)	3	3	6
Chemistry III	2	6	8
*Radiation Protection II (Course 17)	3	4	7
Basic Mechanics	3	3	6
	13	19	32
Fifth Quarter			
Control of Heat Transfer Processes	3	4	7
*Radiation Monitoring Techniques (Radiochemical) (Course 20)	3	4	7
Computer Systems	2	3	5
Electro-Mechanical Controls	3	3	6
*Nuclear Chemical Processes (Course 23)	2	4	6
	13	18	31
Sixth Quarter			
Occupational Safety and Health	3	3	6
*Nuclear Systems and Safety (Course 24)	3	3	6
*Radioactive Material Handling Techniques (Course 25)	3	3	6
Special Projects	4	8	12
	13	17	30

*Technical specialty courses for which instructional modules have been developed.

COURSE DESCRIPTIONS

Each course in the curriculum is described to indicate both its content and its relevance to the overall program.

FIRST QUARTER

Introduction to Nuclear Technology.
An introduction to the principles and applications of nuclear energy. Student is introduced to basic principles involved in nuclear radiation, nuclear sources, reactors and fuel cycles. Essential features of a nuclear power plant are discussed. Student also learns how radionuclides and radiation have application in industry and medicine. Nuclear safety will be emphasized and radiation effects evaluated. Lab sessions will include field trips, films and guest speakers. (Note: Materials for this course should be obtained from nuclear utility public relations offices.)

*Radiation Physics. An introductory course in basic concepts of nuclear radiation. Main topics covered include atomic and nuclear structure, radioactivity and interaction of radiation with matter. Student is introduced to basic radiation and measuring instruments, including Geiger-Müeller counters and personnel monitoring devices.

Mathematics I.
A course in algebra, geometry and introductory trigonometry. Includes ratios, linear equations, plotting, reading and interpreting graphs and sinusoids. Math labs are problem sessions, preferably conducted by the nuclear faculty.

Fundamentals of Electricity and Electronics.
A study of basic principles of direct current and alternating current, series and parallel circuit analyses utilizing Ohm's and Watt's laws, basic motors, generators and relays.

Introduction to Technical Communications.
An introduction to the nature of communication skills and thinking processes with practical exercises in writing, reading, speaking, spelling and vocabulary as related to technical areas. Emphasis on writing, making reports and utilizing the use of a memoranda.

Elective.

*Technical specialty courses.

SECOND QUARTER

*Radiation Detection and Measurement.
A course in principles and methods used to detect and measure radiation, with emphasis on ionization and scintillation detectors. Statistics of counting will be introduced. Properties of α, β and γ will be studied.

Chemistry I.
Basic chemical principles are introduced, using modern laboratory techniques to demonstrate concepts, including atomic structure of matter, formulae, composition and bonding, the electrical nature of matter, acids, bases, oxides, salts and salt solutions.

*Radiation Protection I.
An introductory course to familiarize student with the field of radiation protection, the art and science of protecting human beings from injury by radiation. Specific topics include dose and exposure measurements and units, biological effects of radiation, Federal Regulations of exposures and internal exposure evaluations.

Mathematics II.
A continuation of Mathematics I; algebra includes logarithms to base 10 and base e and exponentials; geometry and trigonometry emphasizing slopes, rates of change and solutions of equations and problems with transcendental functions.

THIRD QUARTER

Blueprint Reading.
A basic study of industrial blueprints, process flow sheets, piping symbols and instrumentation symbols, schematics, logic diagrams and computer circuitry.

*Introduction to Quality Assurance and Quality Control.
An introductory course in quality assurance and quality control, including such topics as history and purpose of quality control, terms and definitions, codes and standards, publications and quality assurance/quality control procedures.

*Principles of Process Instrumentation.
A course to teach principles of operation, calibration and maintenance of process instrumentation found in electrical power generating plants (includes all non-nuclear instrumentation). Specific topics include flow, temperature and pressure instrumentation.

Chemistry II.
A continuation of General Chemistry I, with more emphasis placed on theory and methods of solution.

*Metrology.
A study of the science of measurement and its applications. Emphasis is placed in precision, accuracy, calibration, and dimensional measurements, using micrometers, vernier gages, depth and height gages, dial indicators, etc.

Elective.

FOURTH QUARTER

Technical Writing.
A study of effective ways of presenting information with emphasis on the use of logs, keeping of records and notebooks, use of graphs, drawings and sketches, and various types of reports.

*Metallurgy and Metals Properties.
An introductory study designed to acquaint student with basic metallurgical concepts and metals properties. Many basic physical properties are discussed and related to the behavior of metals and alloys. A preliminary study of metal structure is initiated. Properties of stainless steel and carbon steel are stressed. Student will be introduced to destructive examination techniques, including nick break, bend, tensile, hardness, impact, fatigue and microsectioning.

Chemistry III.
A continuation of Chemistry II, with emphasis upon specific elements, their compounds and properties.

*Radiation Protection II.
This course is a continuation of Radiation Protection I and includes techniques for personnel monitoring devices, bioassay techniques and record keeping.

Basic Mechanics.
An introductory course in mechanics, to teach mass, force, acceleration, velocity, momentum, energy, power and conversion of units.

FIFTH QUARTER

Control of Heat Transfer Processes.
The dynamics of heat transfer, involving steam, water, air and changes of state, are examined. Basic quantitative relationships are considered. The control requirements of these are stressed utilizing electronic and pneumatic forced balance transmitters, controllers and motorized valves.

*Radiation Monitoring Techniques.
Teaches how to monitor the air, water, and biota (both on-site and off-site) for radiation, with emphasis placed upon sample preparation techniques.

Computer Systems I.
An introduction to digital computers and language (example, Fortran) used for process control and data handling.

Electro-Mechanical Controls.
A study of pneumatics, with emphasis upon switches, relays, mechanical counter and mechanical motor control.

*Nuclear Chemical Processes (Fuel Cycle).
A course designed to extend the basic chemistry taught in the previous quarters to the large-scale chemical processes used in the nuclear industry. Among the subjects taught will be head-end treatment, ion exchange, solvent extraction, precipitation, concentration, centrifugation, enrichment by diffusion and other processes, and waste handling.

SIXTH QUARTER

Occupational Safety and Health.
General introduction to general occupational safety and health. Specific topics include fire control, general safety and rules and regulations, protective clothing, breathing apparatus, toxicology, radiation protection and administration of overall safety program.

*Nuclear Systems and Safety.
A basic course in the principles of neutron physics, cross sections, and reactivity, fission process, criticality, inventory management and nuclear safeguard methods with special reference to federal regulations.

*Radioactive Materials Handling Techniques.
A course designed to instruct the student in the use of remote handling equipment and practice in the handling of radioactive materials. Waste disposal, "bag-out" procedures, shipment monitoring and transportation regulations also will be covered.

Special Projects.
This course is designed to allow the student to achieve a higher degree of specialization that would not otherwise be possible. The student will work on a project closely related to his chosen specialty. This course should be taken in the last school quarter.

*Technical Specialty Courses.

TECHNICAL SPECIALTY COURSES AND MODULE TITLES AND DESCRIPTIONS — NUCLEAR MATERIALS PROCESSING

Courses 23 through 25 were developed specifically for the Nuclear Materials Processing curriculum. A description of these courses and the modules in each course follows. The suggested Nuclear Materials Processing curriculum includes (2) courses 1, 2, 3, 11, 14, and 15 from the Nuclear Reator Operator (Trainee) program under separate Contract No. 300760356 and (2) course 27 from the Nuclear QA/QC curriculum developed by General Physics Corporation.

COURSE 23, NUCLEAR CHEMICAL PROCESSES.

Module 23-1, "Head End Processing."

Upon completion of this module, the student should be able to describe the head end of a reprocessing plant, type of remotely-operated equipment, transportation, and accountability of materials. List and describe the interrelationships between safety, criticality and environmental considerations.

Module 23-2, "Ion Exchange."

Upon completion of this module, the student should be able to demonstrate a knowledge of the underlying chemical principles of ion exchange and operate a bench scale ion exchange unit.

Module 23-3, "Solvent Extraction."

Upon completion of this module, the student should be able to demonstrate a knowledge of the underlying chemical principles of solvent extraction and to operate a bench scale solvent extractor.

Module 23-4, "Precipitation Techniques and Centrifugation."

Upon completion of this module, the student should be able to demonstrate a knowledge of the underlying chemical and physical principles associated with precipitation and centrifugation and to operate a bench scale precipitation unit and centrifuge the precipitate.

Module 23-5, "Techniques of Chemical Concentration."

Upon completion of this module, the student should be able to discuss the major techniques used to concentrate liquids and solids and to choose among several methods for a particular use.

Module 23-6, "Diffusion and Enrichment Process."

Upon completion of this module, the student should be able to demonstrate a knowledge of the underlying chemical and physical principles associated with diffusion and other enrichment processes.

Module 23-7, "Nuclear Waste Handling Processes."

Upon completion of this module, the student should be able to discuss the safety aspects of a large-scale waste handling process. The student also should be able to discuss the chemical and physical principles associated with such a waste-handling system.

COURSE 24, NUCLEAR SYSTEMS AND SAFETY.

Module 24-1, "Neutron Physics" (Same as Module 12-1).

Upon completion of this module, the student should be able to demonstrate an understanding of neutron physics, including neutron flux and the necessary hands-on skills to manipulate neutron detection equipment.

Module 24-2, "Cross Sections and Reactions" (Same as Module 12-2).

Upon completion of this module, the student should be able to demonstrate an understanding of cross sections and how they affect nuclear reactions.

Module 24-3, "Fission Rate and Reactor Power" (Same as Module 12-3).

Upon completion of this module, the student should be able to demonstrate an understanding of fission rate, energy produced, reactor power, and how to calculate the reactor power.

Module 24-4, "Nuclear Criticality Control."

Upon completion of this module, the student should be able to discuss the basic criticality information used in the commercial and governmental fuel-cycle area, covering full reprocessing, fabrication, enrichment, transportation and axial conversion steps.

Module 24-5, "Nuclear Material Inventory Management Techniques."

Upon completion of this module, the student should be able to demonstrate a knowledge of the reasons for and systems used for inventory management. The student should be able to utilize correctly at least one inventory system.

Module 24-6, "Nuclear Plant Safeguards."

Upon completion of this module, the student should be able to describe the procedural and physical safeguards used to limit access to nuclear facilities and radioactive materials, and to design a system to control the theft of radioactive material from a given hypothetical facility.

COURSE 25, RADIOACTIVE MATERIAL HANDLING TECHNIQUES.

Module 25-1, "Glove Box Operations – Fundamentals."

Upon completion of this module, the student should be able to demonstrate a knowledge of the reasons and usage of a glove box. The student also should be able to properly remove and replace gloves and to operate the air lock.

Module 25-2, "Glove Box Operations – Advanced."

A continuation of Module 25-1, in which the student learns a more detailed operation of the glove box and becomes more proficient in its usage.

Module 25-3, "Master/Slave Manipulator – Fundamentals."

Upon completion of this module, the student should be able to demonstrate a knowledge of the function, operating principles and usage of master/slave manipulators and to discuss the various types. The student also should be able to remove an object properly from a box and to replace it in the correct receptacle.

Module 25-4, "Master/Slave Manipulator – Advanced."

This module is a continuation of Module 25-3, in which the student gains a knowledge of the detailed operation of the master/slave manipulator and becomes more proficient in its usage.

Module 25-5, "Remote Sampling Techniques."

Upon completion of this module, the student should be able to demonstrate a knowledge of the types, kinds and operation of remote sampling; and be able to successfully manipulate at least two different systems.

Module 25-6, "Radioactive Waste Disposal Procedures" (Same as Module 21-1).

Upon completion of this module, the student should be able to discuss sources of radioactive waste in a nuclear plant, to describe procedures for disposing radioactive materials from a laboratory and from a nuclear power plant, and to cite procedures for disposing of a given radioactive material in a laboratory.

Module 25-7, "Packaging and Monitoring of Radioactive Materials for Shipment" (Same as Module 21-6).

Upon completion of this module, the student should be able to describe procedures for monitoring shipments of radioactive material sent off-site, including compliance with NRC and state regulations; to package and monitor a simulated radioactive waste shipment according to regulations; and to write a set of procedures for a given radioactive material shipment from the laboratory.

Module 25-8, "Measurement of External Radiation Contamination" (Same as Module 21-4).

Upon completion of this module, the student should be able to describe the necessary steps in taking a sample for testing of the exterior surface of a shipping or storage container of nuclear material. The student should be able to take a sample and make the necessary measurements on a shipping/storage cask.

THE NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN CURRICULUM

COURSES

The Nuclear Instrumentation and Control Technician curriculum incorporates learning objectives and supporting objectives based upon related knowledge, as well as upon the tasks that the technician is expected to perform in industry today.

Although the curriculum design specifically relates to training Nuclear Instrumentation and Control Technicians for power plants, every course and every module invites multiple application. An example of the curriculum is provided in Table 10.

TABLE 10. NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN PROGRAM.

	Periods Per Week		
	Lec	Lab	Total
First Quarter			
Introduction to Nuclear Technology	2	3	5
*Radiation Physics (Course 1)	3	3	6
Mathematics I	3	2	5
Fundamentals of Electricity & Electronics	3	3	6
Technical Physics I	3	3	6
	14	14	28
Second Quarter			
*Radiation Detection & Measurement (Course 11)	3	4	7
Technical Physics II	3	3	6
*Radiation Protection I (Course 2)	3	3	6
Mathematics II	2	3	5
Electronic Devices I	3	4	7
	14	17	31
Third Quarter			
Microcomputers	3	3	6
*Introduction to Quality Assurance/Quality Control (Course 14)	2	3	5
Blueprint Reading	1	3	4
*Principles of Process Instrumentation (Course 3)	3	3	6
Electronic Devices II	3	4	7
	12	16	28
Fourth Quarter			
*Power Plant – Thermal (Course 4, Modified only for I&C)	2	3	5
*Introduction to Nuclear Systems (Course 5)	3	4	7
Measurements & Calibrations	2	3	5
*Reactor Physics (Course 12)	3	4	7
Digital Electronics	3	4	7
	13	18	31
Fifth Quarter			
Electro-Mechanical Controls	3	3	6
Linear Integrated Circuits	3	3	6
*Instrumentation & Control of Reactors & Plant Systems (Course 6)	2	3	5
Computer Systems I	2	3	5
*Control Systems I	3	3	6
	13	15	28
Sixth Quarter			
Introduction to Technical Communications	2	2	4
*Control Systems II	3	4	7
Computer Systems II	2	3	5
*Power Plant Electrical Systems & Components (Course 10)	4	8	12
	11	17	28

*Technical specialty courses for which instructional modules have been developed.

COURSE DESCRIPTIONS

Each course in the curriculum is described to indicate both its content and its relevance to the overall program.

FIRST QUARTER

Introduction to Nuclear Technology.
An introduction to the principles and applications of nuclear energy. Student is introduced to basic principles involved in nuclear radiation, nuclear sources, reactors and fuel cycles. Essential features of a nuclear power plant are discussed. Student also learns how radionuclides and radiation have application in industry and medicine. Nuclear safety will be emphasized and radiation effects evaluated. Lab sessions will include field trips, films and guest speakers. (Note: Materials for this course should be obtained from nuclear utility public relations offices.)

*Radiation Physics.
An introductory course in basic concepts of nuclear radiation. Main topics covered include atomic and nuclear structure, radioactivity and interaction of radiation with matter. Student is introduced to basic radiation and measuring instruments, including Geiger-Müeller counters and personnel monitoring devices.

Mathematics I.
A course in algebra, geometry and introductory trigonometry. Includes ratios, linear equations, plotting, reading and interpreting graphs and sinusoids. Math labs are problem sessions, preferably conducted by the nuclear faculty.

Fundamentals of Electricity and Electronics.
A study of basic principles of direct current and alternating current, series and parallel circuit analyses utilizing Ohm's and Watt's laws, basic motors, generators and relays.

Technical Physics I.
An introduction to the principles and applications of the concepts of force, work, rate and resistance. Specific topics in each of these concepts will be discussed with special attention to applications of physical concepts in nuclear power plants. Some specific topics included are: electric and magnetic forces and fields, heat energy, velocity and displacement, flow measurement, fluid resistance and heat flow.

*Technical specialty courses.

SECOND QUARTER

*Radiation Detection and Measurement.
A course in principles and methods used to detect and measure radiation, with emphasis on ionization and scintillation detectors. Statistics of counting will be introduced. Properties of α, β and γ will be studied.

Technical Physics II.
An introduction to the principles and applications of power potential and kinetic energy, force transformers, energy convertors and transducers. Nuclear-power-plant relevant applications are emphasized. Hydraulic power, heat exchangers, pitot tubes, turbines, fluid pumps, electric motors, Bourdon tubes and temperature measuring devices are among the applications used to illustrate physical principles.

*Radiation Protection I.
An introductory course to familiarize student with the field of radiation protection, the art and science of protecting human beings from injury by radiation. Specific topics include dose and exposure measurements and units, biological effects of radiation, Federal Regulations of exposures and internal exposure evaluations.

Mathematics II.
A continuation of Mathematics I; algebra includes logarithms to base 10 and base e and exponentials geometry and trigonometry emphasizing slopes, rates of change and solutions of equations and problems with transcendental functions.

Electronic Devices I.
A study of semiconductor and vacuum tube fundamentals. Mathematical analysis of static characteristics, dynamic characteristics, bias techniques and thermal considerations will be covered.

THIRD QUARTER

Microcomputers.
A course covering general concepts such as computer codes and major parts of most computers, operations and programming with elements of BASIC programming. Specific techniques for introducing and releasing both digital and analog data to microcomputers are reviewed. Data communication ideas and microcomputer troubleshooting techniques are covered.

*Introduction to Quality Assurance and Quality Control.
An introductory course in quality assurance and quality control, including such topics as history and purpose of quality control, terms and definitions, codes and standards, publications and quality assurance/quality control procedures.

Blueprint Reading.
A basic study of industrial blueprints, process flow sheets, piping and instrumentation symbols, schematics, logic diagrams and computer circuitry.

*Principles of Process Instrumentation.
A course to teach principles of operation, calibration and maintenance of process instrumentation found in electrical power generating plants (includes all non-nuclear instrumentation). Specific topics include flow, temperature and pressure instrumentation.

Electronic Devices II.
Analysis of static and dynamic characteristics, frequency effects on amplifiers, large signal amplifiers and d.c. coupled amplifiers. Special purpose devices will be covered with emphasis on digital integrated circuits and their applications.

FOURTH QUARTER

*Power Plant – Thermal.
A study of power plant fundamentals, thermal cycles and the principles of fluid flow and heat transfer processes in nuclear reactor systems.

*Introduction to Nuclear Systems.
This course will include a basic understanding of all major components of the reactor core, pressure vessel, shields, and primary cooling water systems. Differences between PWR's and BWR's will be discussed. The basic nuclear fuel cycle also will be discussed.

Measurement and Calibration.
A study of electronic test instruments, proper use of instruments, accuracy and limitation of measurement and calibration techniques.

*Reactor Physics.
A basic course in the principles of nuclear reactor operation, including fission process, neutron balance, neutron slowdown, criticality and reactor kinetics. Actual characteristics of an operating nuclear power reactor are discussed. (It is highly desirable to use a nuclear reactor or simulator in this course, both as a neutron source in conducting experiments and as a means of gaining hands-on experience.)

Digital Electronics.
A continuation of Electronic Devices II. The further study of digital circuits with emphasis on integrated circuits and their input/output relationships. Troubleshooting techniques will be discussed.

FIFTH QUARTER

Electro-Mechanical Controls.
A study of switches, relays, mechanical counter, mechanical motor control and alarm circuits.

Linear Integrated Circuits.
A study of operational amplifier characteristics, operations, stabilization, testing and feedback techniques for application of operational amplifiers in computation, measurements, instrumentations and active filtering.

*Instrumentation and Control of Reactors and Plant Systems.
A study of nuclear reactor instrumentation systems, nuclear plant controls, control element drive mechanisms, design and operation characteristics of electrical control systems, turbine generation interfaces, and electrical distribution and reactor regulating systems.

Computer Systems I.
An introduction to digital computers used for process control and data handling.

*Control Systems I.
Includes an introduction to block diagrams, review of operational amplifiers, transfer function, input/output devices, pneumatic control mechanisms and control valves.

SIXTH QUARTER

Introduction to Technical Communications.
An introduction to the nature of communication skills and thinking processes, with practical exercises in writing, reading, speaking, spelling and vocabulary as related to technical areas. Emphasis on writing and making reports, utilizing the use of a memoranda.

*Control Systems II.
Includes an introduction to control system theory, transient response, control units, frequency response analysis, operational checks and adjustments, and microprocessor utilization and programming.

Computer Systems II.
A continuation of Computer Systems I, with emphasis on basic upkeep, maintenance, and calibration of process control and data handling computers.

*Power Plant Electrical Systems and Components.
Includes electrical distribution in a typical power plant, instrumentation and control for major plant components, an introduction to display devices, instrument recording devices, process control devices, cathode ray tube systems, preventive maintenance for systems and components and instrument reliability.

*Technical specialty courses.

TECHNICAL SPECIALTY COURSES AND MODULE TITLES AND DESCRIPTIONS — NUCLEAR INSTRUMENTATION AND CONTROL

Courses 33, 34, and 35 were developed specifically for the Nuclear Instrumentation and Control curriculum. A description of these courses and the modules in each course follows. The suggested Nuclear Instrumentation and Control curriculum includes courses 1, 2, 3, 4, 5, 6, 11, 12, and 14 from the Nuclear Reactor Operator (Trainee) program under separate Contract No. 300760356.

COURSE 33, CONTROL SYSTEMS I.

Module 33-1, "Introduction to Block Diagrams."

Upon completion of this module, the student should be able to represent a given system in block diagram form, define applicable terms, translate an algebraic equation into block diagram form, draw and label the canonical form of a feedback control system. The student will perform exercises in the use of block diagrams, representing physical systems, locate and simplify block diagrams in relevant publications such as periodicals, manufacturers' literature and other system descriptions.

Module 33-2, "Input/Output Devices."

Upon completion of this module, the student should be able to define applicable terms, describe the operation of selected transducers, describe input/output relationships for a linear potentiometer and determine the input/output relationship of at least three selected transducers. Laboratory determinations of input/out relationships for selected transducers will be completed.

Module 33-3, "Control System Theory."

Upon completion of this module, the student will be able to describe the objectives of a control system and discuss the operating characteristics of a system in terms of load changes, damping and stability. The student will observe a demonstration of an uncontrolled system, a marginally controlled system and an optimally controlled system. (The schematic and recommended parts list for an electropneumatic trainer that can be constructed by the school will be furnished.)

Module 33-4, "Pneumatic Control Mechanisms."

Upon completion of this module, the student should be able to discuss the theory of a valve type and Linear Aspirating Relays, locate the adjustment for reset/rate of response and pneumatic amplifiers given an electropneumatic control. Characterize modes of control for selected input/output relationships. Laboratory demonstrations of on/off, proportional, rate, integral and multimode operations of a controller will be included.

Module 33-5, "Control Valves."

Upon completion of this module, the student should be able to describe the operation of a pneumatic valve, draw typical characteristic curves of a control valve, determine valve position versus air signal relationship of a valve actuator, size of a valve from given parameters, and discuss valve selection. Students will conduct laboratories using valve selection specifications, equations, tables and nomographs for the selection of appropriate equipment.

Module 33-6, "Process Characteristics (Control Units)."

Upon completion of this module, the student will be able to discuss various modes of control. Practical exercises using the electropneumatic trainer will be conducted with the controller in various modes with different settings. The student will be able to discuss the characteristics of each mode for the processes demonstrated.

COURSE 34, CONTROL SYSTEMS II.

Module 34-1, "Introduction to Transfer Functions."

Upon completion of this module, the student should be able to determine from a given equation — resistance — capacitance — inertia or dead time elements, represent an algebraic equation using Laplace transformations from an input/output equation, express input/output relationships in the time domain, to the frequency domain. The student will conduct Laplace transforms to go from the time to the frequency domains. Given a mathematic relationship of the physical process, the student will be able to use Laplace transforms to obtain the step response and then graph it. The student will empirically determine the step response and the time constants of the process by graph method.

Module 34-2, "Frequency Response Analysis."

Upon completion of this module, the student will be able to draw a Bode diagram for a given transfer function of a single or multi component process. Given a frequency response (Bode diagram), determine the type of process in terms of transfer functions and their time constants.

Module 34-3, "Combination Control Systems."

Upon completion of this module, the student should be able to describe how a control loop or a control system maintains a dynamic process variable at an exact pre-determined condition. The topics covered include the following control types: cascade, ratio, adaptive, and feedforward.

Module 34-4, "Controller Tuning (Operational Checks and Adjustments)."

Upon completion of this module, the student will be able to outline the Ultimate Cycle, Process Reaction and Frequency Response methods of determining controller mode settings. Utilizing the electropneumatic trainer, demonstrate the use of one method for determining settings for one or more control modes.

Module 34-5, "Operational Amplifiers."

Upon completion of this module, the student should be able to describe an amplifier, draw a typical operational amplifier circuit, draw a block diagram from a linear differential equation using operational amplifier circuits. The student will construct operational amplifier circuits on "breadboards" using integrated circuits (IC), verify the theoretical input/output (IO) relationship of a summer, a comparitor and/or other operational amplifier circuits.

Module 34-6, "Microprocessor Utilization."

Upon completion of this module, the student will be able to describe how the microprocessor is used in the system control of a power plant and list the type of hardware used for different utilization. Set up a microprocessor system that simulates selected power plant system changes.

Module 34-7, "Microprocessor Programming."

Upon completion of this module, the student will be able to discuss and describe how microprocessors are programmed to meet power plant system needs and variations. Distinguish between control and computational applications of programming and describe the software requirements for each type of application. Using equipment constructed for Module 34-6, the student will perform simple power plant related programming.

COURSE 35, POWER PLANT ELECTRICAL SYSTEMS AND COMPONENTS.

Module 35-1, "Electrical Distribution."

Upon completion of this module, the student should be able to describe where a.c. and d.c. currents are used, plant arrangement of service buses and ESF's (Engineered Safety Features),

diesel generator systems and ESF for emergency conditions, battery and standby equipment, motors, generators, and motor control centers (MCC) for a typical power station.

Module 35-2, "Instrumentation and Control for Major Power Plant Components."

Upon completion of this module, the student should be able to describe the instrumentation and control (using necessary diagrams) for the following major plant components:

- Main turbines.
- Main electrical generator.
- Auxiliary power systems.
- Steam generator.
- Pressurizer.
- pH control of water system to reactor.

The student will prepare an instrumentation and control block diagram for an actual system and describe each major component function.

Module 35-3, "Recording and Display Devices."

Upon completion of this module, the student should be able to describe four different types of display devices and how they are used in the control circuits. List and describe the two different types of continuous recording devices used in instrumentation circuits. Include their relative advantages and disadvantages and how they are used in control circuits. The student will prepare a recommendation list with descriptive materials and drawings for several recording and display devices for the control circuit prepared in Module 35-2.

Module 35-4, "Process Control Loops and Devices."

Upon completion of this module, the student should be able to describe the objective of a control system (closed loop). Draw the basic control diagrams for two power plant systems, describe each component and what it controls. Dynamic behavior of the loop is presented. Student will visit a power plant, describe and trace through typical loop systems, prepare block and schematic diagrams, labeling major items.

Module 35-5, "Cathode-Ray Tube Systems (CRT)."

Upon completion of this module, the student should be able to describe the use of CRT's in power plant control rooms. Given a system from Module 35-2, the student should be able to prepare a diagram of a graphical display that might be used in a plant. Given a coded set of symbols, the student should list the codes to map the display.

Module 35-6, "Preventative Maintenance for Systems and Components."

Upon completion of this module, the student should be able to describe general inspection procedures including safety precautions. Documentation and scheduling methods are included, as well as elements of material control, planning, tagging, quality control and clearing. The student will prepare simple preventative maintenance (PM) schedules and write procedures for assigned equipment using the recommendations from Manufacturers' Manuals.

Module 35-7, "Instrument Reliability."

Upon completion of this module, the student should be able to describe pre-installation verification, installation procedures and checks, calibration of test equipment and preoperational testing. List and describe the major electrical standards and codes required and where they are applicable. The student will calibrate several instruments against a laboratory standard; for example, pressure, temperature and flow devices.

APPENDIX B

TABLE OF CONTENTS FROM THE INSTRUMENTATION AND CONTROL SUGGESTED PROGRAM PLANNING GUIDE

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APPENDIX C

COPIES OF THE FIVE NUCLEAR INFORMATIONAL LEAFLETS

NUCLEAR TECHNOLOGY PROGRAM

RADIATION PROTECTION TECHNICIAN

POSTSECONDARY TECHNICAL CURRICULUM

53

RADIATION PROTECTION TECHNICIAN

A Radiation Protection Technician helps protect people and the environment from unwanted effects of ionizing radiation.

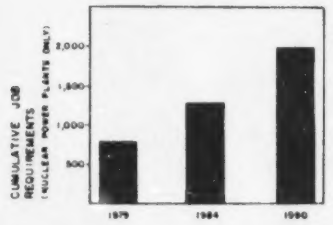
Nuclear radiation cannot be detected with the unaided senses; it cannot be seen; it cannot be felt. Special instruments must be used to detect its presence. Radiation Protection Technicians are expert in the use of these instruments. These men and women monitor radiation levels, measure intensity and identify types of radiation.

The work is demanding and requires patience and a high level of dedication and skill. Radiation Protection Technicians perform a variety of jobs, ranging from routine radiation monitoring to sample collection and advanced radio-nuclide analysis. They help train workers in the proper use of monitoring and safety equipment. They maintain records of personnel exposure and environmental releases. They act as "advance scouts" by performing radiation protection surveillance for maintenance crews. The emphasis is on protection and safety. The need for well trained technicians is pressing.

POTENTIAL EMPLOYERS

Nuclear Electric Utilities.
Nuclear Research Reactor Facilities.
Nuclear Materials Handling and Processing Facilities.
Federal and State Regulatory Agencies.
Nuclear Medicine Units at Larger Hospitals and Clinics.
Non-Destructive Testing Firms.
Radio Pharmaceutical Industries.
Nuclear Waste Handling Facilities.
Nuclear Service Firms.
Nuclear Shipyards.

PROJECTED NEEDS



These technicians are needed wherever radioactive materials are used: in research, industry, medicine, agriculture and in the generation of electrical power. The demand is growing rapidly. By 1990 more than 2,000 trained technicians should be employed in the radiation protection field in nuclear power plants.

More technicians will be needed in processing plants, research centers, hospitals and the many other places where the levels of ionizing radiation must be monitored. Employment of these technicians should expand further as more uses for radioactive materials are developed.

OTHER NUCLEAR OCCUPATIONS

Equally challenging and rewarding opportunities exist for technicians in other specialties within the nuclear industry. Upon completion of the appropriate nuclear technician program, a graduate could work as a:

Nuclear Materials Processing Technician — Performs various tasks in the fabrication, safe handling, reprocessing, transportation and storage of nuclear materials and fuels.

Nuclear Reactor (Plant) Operator Trainee — Controls the operations of an electricity-generating nuclear reactor.

Nuclear Instrumentation and Control Technician — Inspects, calibrates, maintains and repairs nuclear power plant control instrumentation.

Nuclear Quality Assurance and Quality Control Technician — Tests, inspects and audits materials, equipment and procedures in a nuclear facility.

NUCLEAR COURSE INFORMATION

The U.S. Office of Education has provided for a series of nuclear technology curricula for five nuclear occupations. These curricula consist of 35 technical courses. The courses, designed for two-year postsecondary programs, but equally useful in industry, are flexible, performance oriented and tailored to the needs and aptitudes of technical students.

The courses are job-oriented. A national steering committee, drawn chiefly from industry, prepared guidelines for each curriculum and reviewed the modules and courses.

The courses are written with technical students in mind. They avoid unnecessary theory and provide the kind of "hands-on" training technical students need.

The courses can be used by industry. They offer the performance based instruction industry needs to train its employees.

A description of this curriculum, including suggested program and implementation procedures will be available by Spring, 1980. A description of the Nuclear Reactor (Plant)

NUCLEAR TECHNOLOGY PROGRAM

NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN

POSTSECONDARY TECHNICAL CURRICULUM

NUCLEAR INSTRUMENTATION AND CONTROL TECHNICIAN

A Nuclear Instrumentation and Control Technician is a specialist in the maintenance and repair of instrumentation and control systems used in a nuclear facility. The work demands a broad background in electronics, mechanics and mathematics and a specific knowledge of advanced instrumentation and control systems.

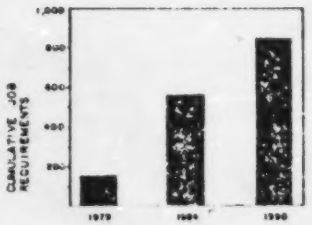
Men and women who are students of this technology study electronics, thermal and fluid systems, instrumentation, radiation protection, reactor systems, computer systems, mathematics and mechanics, and they acquire an extensive knowledge of nuclear instrumentation.

Upon employment, graduates will be taught many specific job-related tasks. Their intensive backgrounds in electronics and their knowledge of nuclear instrumentation and control systems should allow them to do well in this on-the-job training. After this preparation, they should become valuable assets to firms that employ them.

POTENTIAL EMPLOYERS

Electric Utilities.
Nuclear Instrumentation and Control Component Manufacturers.
Nuclear Research Reactor Facilities.
Nuclear Materials Handling and Processing Facilities.
Nuclear Power Plant Contractors and Consultants.
Other Electronic and Instrumentation Industries.

PROJECTED NEEDS



By 1990, a thousand Nuclear Instrumentation and Control Technicians will need to have been added to the workforce. Many of the trainees currently recruited by industry for this technology have electronic and instrumentation backgrounds but lack training in radiation protection and nuclear instrumentation. When implemented, this curriculum should help fill the need for trainees prepared in these additional fields. Graduates should be very attractive to nuclear employers, and be in demand in many phases of the electronics industry.

OTHER NUCLEAR OCCUPATIONS

Equally challenging and rewarding opportunities exist for technicians in other specialties within the nuclear industry. Upon completion of the appropriate nuclear technician program, a graduate could work as a:

Radiation Protection Technician – Helps protect people and the environment from the unwanted effects of ionizing radiation. Monitors radiation levels, measures intensity and identifies types of radioactivity.

Nuclear Materials Processing Technician — Performs various tasks in the fabrication, safe handling, reprocessing, transportation and storage of nuclear materials and fuels.

Nuclear Quality Assurance and Quality Control Technician — Tests, inspects and audits materials, equipment and procedures in a nuclear facility.

Nuclear Reactor (Plant) Operator Trainee – Controls the operations of an electricity generating nuclear reactor.

NUCLEAR COURSE INFORMATION

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NUCLEAR TECHNOLOGY PROGRAM

NUCLEAR MATERIALS PROCESSING TECHNICIAN

POSTSECONDARY TECHNICAL CURRICULUM

NUCLEAR MATERIALS PROCESSING TECHNICIAN

A Nuclear Materials Processing Technician performs various tasks in the fabrication, safe handling, reprocessing, transportation and storage of nuclear materials and fuels. The work requires a background in chemistry and a special knowledge of radiation protection and nuclear chemical processes. Technicians who work as operators in radio chemical plants must be licensed by the Nuclear Regulatory Commission (NRC).

Candidates for licensing as chemical operators must first be employed by a radiochemical facility and trained in the specifics of their operations.

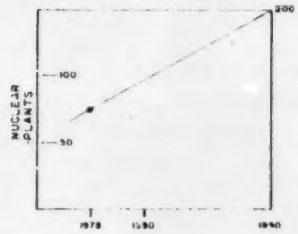
Training technicians is a costly undertaking for the firms that employ them. Therefore, candidates are selected with great care. Experience in hiring these technicians indicates that two-year technical schools are excellent sources of trainees.

POTENTIAL EMPLOYERS

Nuclear facilities.
- Fuel Fabrication.
- Enrichment.
- Reprocessing.

Nuclear Research and Development Organizations.
Other Chemical Industries.

PROJECTED NEEDS



Licensed technicians are needed for the delicate and complex processes of handling nuclear fuels and materials. Demand for these men and women should increase with each new nuclear facility. In 1978, 72 nuclear power plants were operational in the United States. By 1990, this number is expected to exceed 200. Nuclear Materials Processing Technicians will be needed to help provide the fuel for these plants. They should also be in demand in nuclear research and development. Their extensive backgrounds in chemistry should also help them obtain positions as chemical and laboratory technicians in non-nuclear chemical laboratories.

OTHER NUCLEAR OCCUPATIONS

Equally challenging and rewarding opportunities exist for technicians in other specialties within the nuclear industry. Upon completion of the appropriate nuclear technician program, a graduate could work as a:

Radiation Protection Technician — Helps protect people and the environment from the unwanted effects of ionizing radiation. Monitors radiation levels, measures intensity and identifies types of radioactivity.

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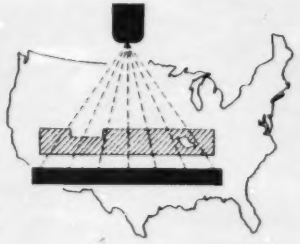
NUCLEAR TECHNOLOGY PROGRAM

NUCLEAR QUALITY-ASSURANCE AND QUALITY-CONTROL TECHNICIAN



POSTSECONDARY TECHNICAL CURRICULUM

NUCLEAR QUALITY-ASSURANCE/ QUALITY-CONTROL TECHNICIAN

A Nuclear Quality-Assurance/Quality-Control Technician (QA/QC) performs tests, checks and audits in a nuclear facility to ensure compliance with technical specifications and procedures. This technician assumes a responsibility in the effort to assure that a nuclear facility is constructed, operated and maintained correctly. The work requires a specific nuclear background as well as a grounding in the fundamentals of civil, mechanical and electrical quality assurance and control.

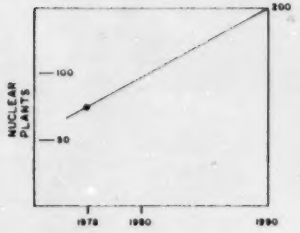
Men and women who enroll in this curriculum study the principles of quality assurance and control. They study nondestructive testing techniques and civil, structural, electrical and mechanical inspection programs. They must also acquire a working knowledge of nuclear systems and components and an understanding of the basics of electricity, chemistry, metallurgy and electronic instrumentation.

Upon employment, graduates must be taught specific job-related tasks. Because of their broad background in nuclear systems and rigorous grounding in the techniques of nuclear quality assurance and control, they should do well in this on-the-job training.

POTENTIAL EMPLOYERS

Nuclear Electric Utilities.
Power Plant Construction Contractors and Consultants.
Nuclear Materials Handling and Processing Facilities.
Manufacturers of Components for Nuclear Facilities.
Non-Destructive Examination Firms.
General and Specialty Contractors.
Architectural and Engineering Firms.

PROJECTED NEEDS



As more and more nuclear power plants are constructed, more QA/QC technicians should be needed. By 1990 more than 200 nuclear power plants are expected to be operational in the United States, almost three times as many as in 1978.

QA/QC technicians also should find employment in other nuclear facilities and with nuclear component manufacturers. Employment as non-nuclear QA/QC technicians is also available.

RELATED NUCLEAR OCCUPATIONS

Equally challenging and rewarding opportunities exist for technicians in other specialties within the nuclear industry. Upon completion of the appropriate nuclear technician program, a graduate could work as a:

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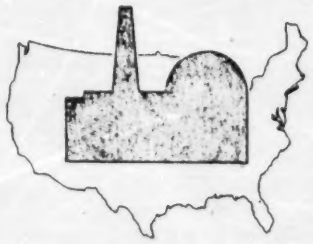
The courses can be used by industry. They offer the performance based instruction industry needs to train its employees.

A description of this curriculum, including suggested program and implementation procedures will be available by Spring, 1979. A description of the Nuclear Reactor (Plant) Operator curriculum is available now. Program planning guides for the other three occupations will be available in Spring 1980. These materials may be obtained from Technical Education Research Center, 4201 Lake Shore Drive, Suite 111, Waco, Texas 76710.

NUCLEAR TECHNOLOGY PROGRAM

NUCLEAR REACTOR (PLANT) OPERATOR TRAINEE



POSTSECONDARY TECHNICAL CURRICULUM

NUCLEAR REACTOR (PLANT) OPERATOR TRAINEE

A Nuclear Reactor (Plant) Operator Trainee is prepared in fundamentals of nuclear reactor and power plant operation. This trainee is prepared for a position in an industrial or research reactor operator training program. Upon completion of these programs and award of a license, a man or woman is qualified as a Nuclear Reactor Operator for a specific reactor.

To be licensed by the Nuclear Regulatory Commission, a candidate nuclear reactor operator must pass comprehensive oral and written examinations.

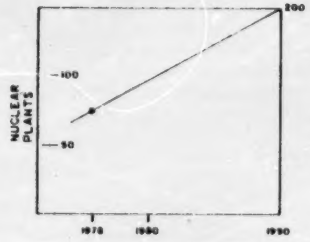
Licensing requirements stipulate that a candidate reactor operator must not only be trained in the operation of a nuclear power plant or research reactor but also have several years of specific plant job experience and training. Because of these requirements, reactor operator trainees may learn only the fundamentals of reactor operation at two-year postsecondary institutions. They will receive experience and specific plant and reactor training after they are employed.

POTENTIAL EMPLOYERS

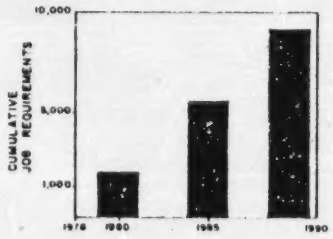
Nuclear Electric Utilities
Nuclear Research Reactor Facilities.
- Government owned
- University
- Private

Federal and State Regulatory Agencies

PROJECTED NEEDS



In 1978, 72 nuclear power plants were operational in the United States. By 1990, this number is expected to exceed 200. Each new plant will require approximately 32 licensed operators. Existing units will require additional staffing to replace operators lost due to attrition (est. 8%/year). Between 500 and 1,000 newly licensed operators will be needed each year.



OTHER NUCLEAR OCCUPATIONS

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APPENDIX D

COPY OF BROCHURE ANNOUNCING DENVER NATIONAL WORKSHOP
ON NUCLEAR (AND COAL) CURRICULA AND MATERIALS

TRAINING IS NEEDED

Almost 400 new electrical power plants are scheduled to begin operating in the 1980's. This huge growth in the electric utility industry will require a large influx of highly skilled technicians and operators of plant equipment.

In addition, workers in plants that are already operational will need to upgrade their skills and competencies to improve plant efficiency, reliability, and safety. New and improved training programs are needed to prepare an adequate supply of new workers and to upgrade the present workforce for this highly critical energy industry.

Most training programs are currently being conducted by utility companies for their employees. These programs are expected to continue to grow and become more comprehensive. But to meet the new demands for training an emerging workforce assistance must be provided by postsecondary institutions – technical institutes and community colleges. Pre-employment educational programs should be established as well as course offerings for training and retraining existing utility company employees. For this type training close cooperation between utility companies and schools is essential.

WORKSHOP OBJECTIVES

In response to the need for increased and upgraded training, the Center for Occupational Research and Development will conduct a two-day workshop, August 14 and 15, in Denver, Colorado. The objectives of the workshop are to:

- Describe job needs, job requirements, model curriculum designs, and program implementation procedures.
- Present and describe curriculum planning guides, resource handbook, and instructional materials.
- Organize local or regional working groups of employers and educators to discuss approaches to cooperative training efforts.

BENEFITS

- Avoid duplication of program and course development.
- Receive information on availability of course materials and planning documents.
- Review curricula, courses, and instructional materials specifically designed for power plant employee training.

WHO SHOULD ATTEND?

Employers, training managers, teachers, and institutional program planners interested (or already involved) in training technicians and/or operators for work in nuclear and coal-fired power plants and related occupations.

WORKSHOP REGISTRATION

Fee for the two-day workshop (including luncheons and materials) is $40.00. Participants should register by mailing registration form and fee to:

WORKSHOP COORDINATOR
CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT
4800 LAKEWOOD DRIVE
WACO, TEXAS 76710
817/772-8756

ACCOMMODATIONS

PLAZA COSMOPOLITAN HOTEL
1780 BROADWAY
DENVER, COLORADO 80202
303/861-8000

Limousine service to the hotel and airport is available.

Please refer to the Workshop when making your reservations and use the enclosed card.

SPONSORS

EPRI THE ELECTRIC POWER RESEARCH INSTITUTE– founded in 1972 by the nation's electric utilities, develops and manages research activities for improving electric power production, distribution, and utilization. EPRI is particularly interested in cost effective programs which improve plant efficiency and reliability. For the past two years EPRI has sponsored research leading to the curricula design and materials development for coal-fired utilities.

U.S. DEPARTMENT OF EDUCATION– formed on May 7, 1980, incorporates all the responsibilities of the U. S. Office of Education (USOE) as well as numerous other educational agencies and offices in the federal government. One of the USOE functions that was transferred was that of the Bureau of Occupational and Adult Education, which provided financial support for Nuclear Technology curricula design and material development, under the Programs of National Significance.

WORKSHOP COORDINATOR

CORD THE CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT – is a nonprofit corporation that conducts research, development, evaluation and dissemination activities in postsecondary education and training for technical occupations. For the past six years, CORD has been working with various utilities and schools to develop model curricula and instructional materials to be presented at this workshop.

CORD (formerly Technical Education Research Center–Southwest) indentifies workforce needs in new and expanding occupations and develops program plans and instructional materials to be used by two-year institutions that provide specialized training programs. Once programs and materials have been developed, CORD assists schools and industry in implementing the programs and adapting them to meet local need.

NEW TRAINING COURSES AND MATERIALS FOR COAL AND NUCLEAR PLANTS ARE AVAILABLE

Modern power plants have become increasingly complex in the past decade, however most of the skills and knowledge requirements (and training) for a particular technician or operator job classification do not vary from one plant to another. To avoid unnecessary duplication in developing training from one utility or school to another, and to provide some standardization in training, curriculum models have been designed and course descriptions and instructional materials have been identified and/or developed for use by utility employers and schools across the country. The relevance and accuracy of these programs have been assured by national advisory committees, representing the following utility companies, schools, government agencies and institutions:

Electric Power Research Institute	U. S. Department of Education	Southern States Energy Board
Arkansas Power and Light	U. S. Department of Energy	IBEW
Carolina Power and Light	U. S. NRC	Western Interstate Energy Board
Commonwealth Edison	Babcox and Wilcox	Aiken Technical Education Center
Detroit Edison	General Electric	Albuquerque TVI
Duke Power	Westinghouse	Camden County College
Georgia Power	Offshore Power Systems	Columbia Basin College
Niagara Mohawk	AFC Industries, Inc.	Lakeshore Technical Institute
Portland General Electric	H. B. Zachry Company	Memphis State University
Public Service Elec. & Gas Co. of N.J.	Ebasco Service, Inc.	Mississippi Gulf Coast J.C.
Public Service Co. of New Mexico	Air Force Weapons Laboratory	Terra Technial College
San Antonio Public Service	Battelle Laboratories	Texas State Technical Institute
Tennessee Valley Authority	Oak Ridge National Laboratory	Tri County Technical Institute
Texas Utilities	Los Alamos Scientific Lab.	University of Arkansas
Utah Power and Light	Sandia Laboratory	University of North Carolina
Washington Public Power	Argonne Laboratories	Utah Technical College

The curricula, course designs, and instructional materials are based on task inventories of the specific jobs, and have been verified by the employers listed above. Course designs have relied heavily on the experience of those utilities with major training efforts. All courses and instructional materials have been designed in a "modular" format so that training organizations can select only topics relevant to their needs and add "site specific" information on equipment and procedures, thereby tailoring the curriculum models and courses to local employer/plant requirements.

Nuclear

- Training programs and courses, suitable for post-secondary institutions and utility company employee training, have been designed for the following job categories:
  - Radiation Protection Technician
  - Nuclear Instrumentation and Control Technicians
  - Nuclear Reactor (plant) Operator Trainee
  - Nuclear Quality Assurance and Quality Control Technician
  - Nuclear Materials Processing Technician (Materials Processing/Reprocessing Plants).
- Five Program planning guides have been developed, containing task inventories, curricula, course descriptions, laboratory designs, and training equipment.
- 235 instructional modules (over 7000 pages) have been prepared for all the technical specialty courses in the five programs.

Coal

- Training programs and courses, suitable for postsecondary institutions and utility company employee training, have been designed for the following job categories:
  - Power Plant Operator
  - Instrumentation and Control Technician.
  - Environmental and Chemical Analysis Technician.
- Program planning guides have been prepared for all three categories, containing detailed task inventories and course outlines.
- A Training Resource Guide has been prepared containing listings, descriptions, and availability information on 732 instructional materials (printed, audiovisual, and self taught) which can be used in the three training programs.
- Modular instructional materials are being developed to be used specifically in the curricula listed above. Field-test sites for these materials are being sought for this fall.

AGENDA

Wednesday, August 13
7:00 - 10:00 PM Registration

Thursday, August 14
8:00 AM Registration
9:00 AM Welcome, Introduction
- Projected Industry Growth
- New Workforce Needs
- Retraining/Upgrading Requirements

Noon - Lunch
1:15 PM Training Operators and Technicians for Coal-Fired Power Plants
- Job Descriptions
- Task Inventories
- Model Curricula
- Course Designs
- Implementations

(for the following job categories):
- Environmental and Chemical Analysis Technician
- Instrumentation and Control Technician
- Power Plant Operator

Resource Handbook and Library on Available Training Materials

Friday, August 15
9:00 AM Training Technicians for Nuclear Plants
- Job Descriptions
- Task Inventories
- Model Curricula
- Implementations
- Instructional Materials

(for the following job categories):
- Nuclear Reactor Operator Trainee
- Instrumentation and Control Technician
- Radiation Protection Technician

Noon - Lunch
1:15 PM Training Technicians for Nuclear Industries
- Materials Handling Technician
- Quality Assurance/Quality Control Technician

2:00 PM Regional Employer-School Conferences

REGISTRATION FORM
August 14 & 15, 1980

Name _____ Phone ( ) _____
Home Address _____
City _____ State _____ Zip _____
Affiliation _____
Business Address _____
City _____ State _____ Zip _____
Phone number where I may be reached one week prior to Workshop ( ) _____
Method of Payment: ☐ Personal Check enclosed. ☐ Registration will be paid at the Workshop.
☐ Company/school is forwarding check by _____

If you have registered by phone, please complete the above form and return it with your check or purchase order.